Corporate Financial Reporting and Disclosure

A Behavioral Finance Perspective

Dissertation
for the Faculty of Economics, Business Administration and Information Technology of the University of Zurich

to achieve the title of
Doctor of Economics

presented by

Kremena Bachmann

from Sofia (Bulgaria)

approved at the request of

Prof. Dr. Thorsten Hens
Prof. Dr. Michel Habib

The Faculty of Economics, Business Administration and Information Technology of the University of Zurich herewith permits the publication of the aforementioned dissertation without expressing any opinion on its views.

Zurich, December 5, 2007

The Dean: Prof. Dr. H. P. Wehrli

To Vivien

Acknowledgements

During my thesis I have been supported by many people to whom I would like to express my sincere thanks. I owe my most sincere gratitude to my supervisor Prof. Dr. Thorsten Hens for the constructive discussions, insightful comments and thoughtful advice. His understanding and personal guidance helped me to overcome difficulties and to find the solutions I was looking for. His research ideals and conceptual approach have had a remarkable influence on my entire work as a young researcher. My sincere thanks are also due to my co-referee Prof. Dr. Michel Habib for his detailed review and excellent advice in the final stage of preparing this thesis.

I also wish to thank Dr. Peter Woehrmann for helping me to gain insights into advanced empirical and numerical methods. His constructive guidance, fruitful ideas and kind support have been of great value for the empirical part of this thesis.

Further, I wish to express my warm thanks to Prof. Dr. Anke Gerber for her valuable advice and friendly help. The extensive discussions around the second part of this thesis and her constructive criticism have been very helpful for the achieved advancements.

During my time at the University of Zurich and the Institute for Empirical Research in Economics I had the opportunity to receive valuable comments from many colleagues (listed here in alphabetical order) for whom I have great regard: Dr. Reto Foellmi, Dr. Carsten Murawski, Dr. Stefan Reimann, the participants of the brown bag lunch seminar at the University of Zurich and the participants of the fifth doctoral workshop in finance in Gerzensee.

Financial support for the research presented in this thesis was provided by the National Center of Competence in Research ”Financial Valuation and Risk Management” (NCCR FINRISK) and is gratefully acknowledged. The national centers in research are managed by the Swiss National Science Foundation on behalf of the federal authorities.

Last but not least, I owe my loving thanks to my husband Christoph. Without his encouragement, understanding and love it would have been impossible for me to finish this work. My special gratitude is due to my parents and in particular to my mother whose good example was a motivation for me to start doing research.

Contents

Appendices

Chapter 1

Introduction

A challenging task for every capital economy is the optimal allocation of resources. There are many managers aiming to attract investors' capital and many investors seeking to allocate their savings to attractive business opportunities. However, matching investors' and managers' preferences appears to be complicated because of conflicting interests and asymmetrically distributed information. Managers are usually better informed than firm's outsiders and they might use their insider advantage to overstate the value of their firms in order to attract more capital and to misuse the investors' savings.

Managers' information disclosure to firm's outsiders plays an essential role for mitigating these problems. A significant part of this information is governed by regulatory authorities imposing minimum disclosure requirements to companies that access the capital markets. The reporting choice available to managers is further regulated by accounting standards that define commonly accepted rules of presenting economic performance to firm's outsiders. If accounting regulation works perfectly, managers accounting disclosure reflects their private information on the real business performance of the firm. However, if accounting regulation is imperfect, which is the most likely case, managers may trade off between making accounting decisions to communicate their superior knowledge to firm's outsiders and to manage the business performance of the firm in order to signal their talent (Chaney and Lewis, 1994), to influence the investors' perception of firm's bankruptcy risk (Trueman and Titman, 1989) or because of their own myopic preferences (Stein, 1989).

In addition to the information that managers are required to provide by regulatory standards, some managers disclose information voluntarily in the form of press releases, earnings forecasts, presentations and discussions during conference calls with financial analysts. Their main motives are capital market driven. By disclosing information voluntarily, managers can reduce the cost of capital, thereby reducing the firm's costs of external financing (Myers and Majluf, 1984) and the premium that investors demand for bearing information risk (Barry and Brown, 1985; Merton, 1987). Further, managers disclose private information to improve the liquidity and to reduce the volatility of firm's shares (Hsieh, Koller and Rajan, 2005).

If managers' compensation contracts are based on the market value of the firm, their incentives to manipulate reporting and to disclose information voluntarily depends significantly on the investors' perception of value reflected in their response to reporting numbers and managers' statements. Deep insights into investors' decision behavior and in particular into the question how investors select and evaluate information is provided by the broad experimental research in behavioral finance. The main findings concerning investors' preferences are summarized in the prospect theory of Kahneman and Tversky (1979). Very briefly, the theory states that agents evaluate outcomes with respect to a certain benchmark and that outcomes below this benchmark are overly disappointing compared to outcomes above it. The prospect theory finds additional support by several empirical studies analyzing the behavior of investors with respect to different benchmarks such as previous earnings (Barth, Elliot and Finn, 1999), the earnings consensus forecast of the analysts following the firm (Kasznik and McNickols, 2002; Degeorge, Patel and Zeckhauser, 2006; Bartov, Givoly and Hayn, 2002; Skinner and Sloan 2002), and zero earnings (Degeorge, Patel and Zeckhauser, 2006). The evidence suggests that the investors' preferences create specific incentives for managers with market based compensation contracts to use the discretion provided by reporting standards and manage performance numbers.

The task of evaluating managers' financial reporting is rather straightforward compared to the processing of managers' voluntary disclosure, since the latter requires the ability to transform general statements into financial figures. Financial analysts are often considered to be the best prepared firm's outsiders able to perform this task. In their aim to improve the precision of their earnings forecasts, they participate in conference calls, have a direct contact with the officers of the firms they follow and try to take advantage of the private information of the managers as firm's insiders. Used as a proxy for shifts in the investors' expectations, changes in the analysts' consensus forecast reflect the impact of managers' voluntary disclosure on the market value of the firm. In particular, they help to establish a direct link between the optimal disclosure policy of the managers and some patterns in analysts' and investors' behavior that can be considered as irrational otherwise.

The main objective of this thesis is to analyze the managers' reporting incentives in a broader context, while considering the preferences of behavioral investors and the active role of financial analysts. Further, this thesis aims to study the optimal disclosure policy of different firms in order to establish a link to the behavior of analysts as information providers. To achieve these goals, this thesis is divided into three parts, each dedicated to a separate question. The parts are connected to each other as they analyze different aspects of the managers' reporting and disclosure incentives and their consequences, but they can be read independently as each part elaborates a research question separately.

The first question we aim to answer is related to the firms' reported earnings and their relevance for the investors' perception of the value of its intangible assets. In particular, we study whether earnings reports above and below the zero threshold have any information content on the firms' ability to employ capital efficiently. If the reported profits are informative for investors, they can be expected to affect the market value of the intangible assets generated by R&D investments for example.

This question is analyzed in the first part of this thesis in the working paper

”Corporate Profits and the Market Value of R&D Investments”. The evidence suggests that managers reporting earnings above the zero threshold receive a higher valuation for their R&D activities than managers reporting earnings below the zero threshold. The investors appear to disregard the optimism of managers boosting R&D investments in the face of negative profits and prefer to focus on the risks associated with such investments. In general, this effect remains stable over time, but the investors’ sensitivity to shifts in R&D investments and earnings changes over the business cycle. Therefore it is possible that the managers’ incentives to manipulate earnings change with the R&D investment cycle as well.

The managers’ motivation to manipulate reported earnings is analyzed in the second part of this thesis. The question is studied theoretically in the working paper ”The Earnings Game with Behavioral Investors”, which is a joint work with Thorsten Hens. To be more realistic, the managers’ reporting respectively manipulation problem is studied in an inter-temporal context with analysts trying to uncover the managers’ manipulation. The analyzed strategic game allows to derive conclusions on the managers’ incentives to manipulate earnings reports in dependence on three factors. The first one is the investors’ preferences towards earnings reports above and below the analysts’ consensus forecast. In our model, this threshold is not exogenously given but determined by the best response of the analysts that behave strategically. The second factor we consider is the managers’ compensation. Finally, we analyze how the managers’ incentives to manipulate earnings changes when managers disclose information voluntarily in order to guide the earnings expectations of the firm’s outsiders. The analysis shows that given the asymmetric investors’ reaction to earnings surprises reported in empirical studies, managers have strong incentives to manipulate earnings. In dependence on their time preferences, managers may choose to manipulate earnings in order to match the consensus forecasts. In this equilibrium, rational investors are systematically fooled. Assuming that managers’ preferences are equally distributed in the economy, we also derive conclusions on how the absolute level of manipulation in the economy changes with the investors’ preferences, the managers’ compensation package and the earnings guidance they may provide to analysts.

If managers disclose information systematically in order to guide the analysts in their effort to estimate the next period earnings, analysts’ forecasts and forecast errors may exhibit certain patterns, which are expected to be related to the managers’ disclosure incentives. This question is studied in the last part of this thesis in the research paper ”Managers Guidance and Analysts Underreaction”, which is a joint work with Peter Woehrmann. The paper is motivated by the evidence provided in several empirical investigations indicating the existence of significant time varying biases in the earnings forecasts of financial analysts. These biases are usually attributed to the analysts’ liability to cognitive limitations. For example, a positive autocorrelation of analysts’ forecast errors is commonly explained by analysts’ underreaction. We develop a random dynamical system describing the evolution of analysts’ forecasts and firm’s prices and show that managerial guidance is capable to explain such inefficiencies in the analysts’ forecasting behavior. This result is well supported by empirical tests. In particular, we find that the managers of growth firms guide stronger than the managers of value firms, which allows further conclusions on the precision and efficiency of earnings forecasts released for value and growth stocks in line with the existing literature.

Overall, this thesis contributes to the broad research on behavioral corporate finance studying the determinants and consequences of managers' decisions when managers and (or) investors suffer cognitive biases and (or) have behavioral preferences.[1] In this thesis, we focus on the investors' preferences as described in the prospect theory of Kahneman and Tversky (1979) and neglect any cognitive biases that might lead to irrational decisions. Our contribution is threefold. First, we contribute to the empirical literature on the relevance of thresholds by showing that reported performance, particularly around the zero target, influences the market value of a firm and in particular the investors' perception of the value generated by R&D investments. Second, we extend the theoretical literature on earnings manipulation by analyzing the managers' reporting incentives in a strategic game where managers' payoff is determined by investors using the analysts' consensus forecast as a target when evaluating firm's reported earnings. Finally, instead of adapting the view that agents suffer some cognitive limitations, this thesis contributes to the literature that seeks explanations for the analysts' underreaction by offering a rational economic explanation for their forecasting behavior.

[1]There are several surveys on this topic, see for example Shefrin (2001) or Baker, Ruback and Wurgler (2004).

Chapter 2

Corporate Profits and the Market Value of R&D Investments

2.1 Introduction

The market value of firm's shares reflects the value of all its net assets. In some industries, the main part of the firm's value may reflect primarily its intangible assets representing a non-physical claim on future cash flows, e.g. patents, copyrights, trademarks. The most commonly used indicator of cumulated intangibles is research and development (R&D) expenditures. R&D investments contribute directly to the development of new products and aid indirectly the successful adoption of technologies developed outside the firm. In particular, R&D investments aim to improve the profitability of the firm.

The impact of R&D investments on the future economic performance of the firm is highly unpredictable since it is affected by market and technology uncertainty but also by firm's ability to exploit emerging opportunities created by the uncertain environment.[1] The firm's ability to manage the uncertainties in its environment successfully is particularly important for the valuation of its R&D projects because R&D projects become profitable only when the goods in which the R&D is embodied are sold and productivity gains are realized. Thus, in knowledge–driven industries investing in R&D on a continuous base the earnings companies generate are not only a capital constraint but also an indicator for firm's ability to employ R&D capital profitably. If this signal is informative then the value of R&D investments would vary among firms with different profits.

The current paper examines whether the reported pre–R&D earnings (or profits) influence the investors' perception on the value of firm's R&D expenditures. The results of the empirical tests indicate that firms with positive profits receive a higher market rent for their R&D activities than firms with negative reported profits. This suggests that simply boosting R&D expenditures would not be enough to generate higher growth expectations and the market value of the firm would not increase proportionally to firms' R&D expenditures. Further, comparing the R&D elasticity of firms with different profits, the results indicate that investors do not fully share the

[1] There are certainly significant interactions between these effects, though the complexity of the relationships suggest to focus initially on the firms' characteristics reflected in their accounting reports.

strong optimism of managers deciding to invest in R&D projects under the pressure of low current profits and cutting costs. Instead, investors appear to be more concerned with the risks associated with the R&D investments and the possibility that managers ”throw good money after bad”. In general, this effect remains stable over time, but the investors’ sensitivity to shifts in R&D investments and profits changes over the business cycle. Therefore, it is possible that managers’ incentives to manipulate the reported profits follow the R&D investment cycle.

Previous studies on the relationship between R&D investments and market value has identified two main reasons why R&D investments might influence the market value of the company. The first link between expected returns and R&D arises from the notion that R&D expenditures create intangible assets. The idea is based on the theoretical concept that in equilibrium the market value of the firm is equal to the book value of the assets composing the firm. Deviation from this relationship arises either because the market is not in an equilibrium or there is an unmeasured source of rents driving a wedge between the market and book value of the assets (see Hall, 1993). The question, whether this wedge is associated to R&D expenditures has been the subject of several studies. In general, discrepancies in the estimated relationship between firms’ market value and their R&D investments are mainly caused by differences in the variables included in the estimation equation.[2]. The sources of rents considered in addition to R&D expenditures are for example patenting activities (see Griliches, 1981; Megna and Klock, 1993; Pakes, 1985), advertising expenditures, sales growth (see Hall, 1993; Hirschey and Weygandt, 1985), market concentration (see Hirschey and Weygandt, 1985; Jaffe, 1986), or monopoly power (see Johnson and Pazderka, 1993). The particular importance of earnings when estimating the value of R&D expenditures is addressed by Sougiannis (1994). He raises the question whether past R&D expenditures are reflected in the market valuation directly or indirectly through their impact on earnings. His results show that the indirect impact is much stronger than the direct one, i.e. the rents associated with R&D expenditures are better explained by the earnings they generate rather than by the R&D investments themselves.

The second potential link is closely related to the risk characteristics of R&D investments. While the costs affect firms’ profits immediately the benefits are often ambiguous and likely to materialize in subsequent periods if ever. Thus, managers continuing to invest in R&D although previous investments did not return the expected profits are either convinced that their current efforts will be successful or biased because they consider previous investments as ”sunk costs”. As a result, investors may become overoptimistic about the innovative potential of R&D intensive firms systematically overlooking the possibility that many R&D projects are not profitable. On the other hand, if investors are myopic and value firms by the face value of their financial statements, the value of R&D capital will be on average underpriced by the market.

Several studies analyze how do investors value risky R&D investments. Chan, Lakonishok, and Sougiannis (2001) for example analyze the performance of portfolios based on different firm characteristics and conclude that simply doing R&D by itself does not give rise to differential stock price performance, on average. Specifi-

[2]Hall (1999) and Mairesse and Sassenou (1991) provide summaries on the results.

cally, the market appear to be sluggish revising its expectations about the prospects of R&D activities by firms with poor past returns. This result indicates that investors do not share the optimism of managers spending heavily on R&D despite poor market returns and pressure on cost cuts.

Encouraged by the results of Sougiannis (1994) suggesting that investors use earnings to elicit information on the value of R&D expenditures, this study goes further analyzing the question how investors assess the potential profitability of firms' R&D activities in the context of their reported profits. Differences across companies with respect to their profits are reflected in a continuous non-linear function. Using this function as a condition when estimating the value of R&D investments reflected in the market capitalization of the company allows drawing conclusions on investors' sensitivity to changes in firms' R&D investments in the context of continuous profits changes. Characteristics as "high" and "low" profit firms are then not exogenously specified but determined by the data.[3]

This chapter is organized as follows. The formal statement of the problem is provided in section 2. Section 3 describes the sample selection procedure; it also discusses some empirical properties of the data. The results of the estimated equations are discussed in section 4. Section 5 provides an interpretation of the results. The main conclusions are summarized in section 6.

2.2 The Problem

The typical model of market value used in previous studies hypothesizes that the market value of the firm is a function of its assets (see Hall, 1999; Hall and Kim, 1997; Hall and Hayashi, 1989; Johnson and Pazderka, 1993). There are two types of assets: tangible assets TA (e.g. physical capital) and intangible assets IA (e.g. patents, copyrights, knowledge capital). Thus, the market value of the firm V_t at time t can be expressed as:

$$V_t = f(TA_t, IA_{t-\theta}, IA_{t-\theta+1}, ..., IA_t) \tag{2.1}$$

where f is an unknown function describing how the assets combine to create value.[4] θ is a gestation lag reflecting the idea that the production of knowledge capital is different than the production of capital goods and it is likely to involve projects with durations of several years $\theta = 1, ..., T$, where T reflects the age of the firm.

Adapting a multiplicative separable specification for the function f, the market value function (2.1) can be written as:

$$V_t = (TA_t)^{\beta_1} \sum_{\theta=1}^{T} (IA_{t-\theta})^{\beta_{2,\theta}} \tag{2.2}$$

TA_t are the real assets of the company such as fixed assets and inventories. They are measured by the book values of these items and represent the net capital stock

[3] The idea of using a non-linear relationship when estimating the importance of variables is not new. In a different context, McConnell and Servaes (1985) for example use a quadratic regression and show that the relation between corporate value and leverage is nonlinear, i.e. it is negative for "high" growth firms and positive for "low" growth firms.

[4] This function is linear (in the logs) if assets provide constant returns to scale.

of the company. The value of the intangible assets *IA* are not reported and must be estimated. One possibility to estimate the value of intangible capital is to refer to firm's R&D expenditures and use them as an indicator of innovation and growth power.[5]. Using current and past R&D expenditures as a proxy for intangible capital (2.2) and taking the natural logarithms of both sides, we obtain:

$$\ln V_t = \hat{\beta}_{1,t} \ln TA_t + \sum_{\theta=1}^{T} \hat{\beta}_{2,t} \ln RD_{t-\theta} \tag{2.3}$$

The ratio $\frac{V_t}{TA_t}$, respectively the difference $\ln V_t - \ln TA_t$, reflects the quality of firm's current and anticipated projects as perceived by investors. The company should acquire more assets if the market valuation of those assets is greater then the replacement costs usually reflected in the book value of the assets. In other words, new investments are considered by investors as profitable if they are used so as to create at least as much value as the cost of reproducing the new assets. Therefore, one can learn whether R&D expenditures give rise to intangible capital by simply studying the relationship between firms' R&D investments and their market value.

In the simplest case, this relationship is linear, so that every unit money spent on R&D is transformed in market value by a multiple. Clearly, this multiple can vary across industries and over time as previous studies have already reported. Hall (1999) and Mairesse and Sassenou (1991) provide summaries of the estimated coefficients in dependence on the variables additionally included in the estimation equation. Though, to our knowledge, none of these studies explain how this multiple depends on firm's characteristics. This is important since all investments in R&D are not necessary good, the question is if there are firm specific factors that systematically explain why the market gives more credits to some firms and less to others although all of them invest in R&D. Since R&D expenditures are dedicated to improve the current and future earnings of the firm, the simplest way to learn something about the value of R&D activities is to look at firms' profits. Given that the market differentiates between companies investing in R&D, two firms with different R&D earnings contribution, should also differ in their market valuations.

Various methods aid testing this intuition. The simplest one is to split the sample in firms with high and firms with low profits. The main problem with this approach is that splitting firms requires setting up a certain criteria in advance. Therefore the criteria cannot be endogenously determined. For example, setting the cut off by zero and dividing firms in two groups, one with positive and one with negative earnings, will be inconsistent with the data if investors apply another criteria to order firms. Applying the wrong cut off criteria would lead to rejecting the hypothesis that investors differentiate between firms doing R&D and to the erroneous conclusion that R&D activities by all firms within an industry have the same value. An additional disadvantage of the approach is that dividing firms in groups necessary reduces the sample of observations within each group. This is disadvantageous for interpreting the results in terms of significance.

To overcome the problems associated with applying predefined criteria, we suggest a model based on one equation including all firms in the sample for a given

[5]Several studies demonstrate that R&D expenditures creates intangible capital (see, for example, Hall, 1993; Hirschey and Weigandt, 1985)

period. Differences in firms' profitability can be described using a function with similar properties as the indicator function but without requiring a decision for the cut off point in advance. One candidate with this property is a non-linear function that can 'switch' between zero and one but also allow for the existence of an interval where the function can take values between zero and one. Additionally, the function must include a shift parameter, which determines the cut off or 'switching' level.

One example for a non-linear function with the desired properties is:

$$\psi(X) = (1 + e^{-a-bX})^{-1} \tag{2.4}$$

The function is s-shaped and takes values between zero and one. Its tightness depends on the parameter b. Larger values of b reduce the interval, where the function takes values between zero and one. Then, $\psi(X)$ behaves like an indicator function. The smaller the parameter b, the flatter is the function. In the extreme case, it is linear. a is a shift parameter. It determines the level of X where the function 'switches'. A general form of the function and a discussion on its properties is included in the appendix.

For the purpose of this study testing whether investors evaluate R&D investments of firms in dependence of their profitability, the function $\psi(X)$ is particularly helpful in different aspects. First, it allows to determine the switching point endogenously from the data. This is important for our analysis since we do not know for sure what is 'high' and what is 'low' profitability from investors point of view and over time. Second, since the function is continuous, it allows estimating how the market value of the company changes to small shifts in the R&D expenditures and earnings simultaneously. Third, applying this functional form to estimate the impact of earnings on the market value of R&D, the study is able to draw conclusions on how does R&D elasticity change over time for firms with different earnings levels. Finally, the specification allows testing for non-linear dependence using a linear model.

The model defined in equation (2.3) is extended as follows:

$$\ln V_t = \hat{\beta}_{0,t} + \hat{\beta}_{1,t} \ln TA_t + \hat{\beta}_{2,t} \ln RD_t + \hat{\beta}_{3,t} \psi(X_t) \ln RD_t + \varepsilon_t \tag{2.5}$$

where X_t is a random variable reflecting the earnings of the company in time t.[6] The difference to the linear model in equation (2.3) is in the third term. It introduces an *indirect* relationship between R&D investments and market value as a non-linear function of firm's profitability measured by X_t. This relationship is different from the indirect relationship studied by Sougiannis (1994) in two aspects. First, it is simultaneously determined by one equation instead of a system of equations stating first the link between R&D investments and earnings and then between earnings and market value. Second, it allows drawing conclusions on the value of R&D investments conditioned on earnings. In contrast, applying the system of equations as used by Sougiannis (1994) one can compare the informativeness of earnings and R&D for investors valuing the R&D activities of the firm. However, conclusions on the particular impact of earnings on the value of firms' R&D investments are not offhand possible.

[6] Alternatively, one can take other profitability measures, e.g. operating profits. Though, the basic results (not reported here) do not differ substantially.

Since product development usually takes several years an additional issue when explaining the link between the market value of the firm and its R&D activities is the importance of previous R&D investments. The problem is the exact deprecation rate, respectively the percentage of past R&D investments, which are still associated with earnings growth in the future as reflected in the market price of the company. An alternative to using lagged R&D investments as indicator for expected profit growth is to focus on realized profit reflecting previous R&D investments returning products that increase the profit as previously expected by investors. A necessary condition for this argument to hold is that firms' profits are strongly research-driven and firms invest in R&D on a regular basis. If firms invest in R&D occasionally, the earnings in the next period would not reflect their profitability correctly since product development usually takes several years. However, if firms run various R&D projects requiring continuous investing in R&D, the observed earnings reflect these projects that were successful.

To capture the effect of previous R&D investments in the model, equation (2.5) is modified slightly to:

$$\ln V_t = \hat{\beta}_{0,t} + \hat{\beta}_{1,t} \ln TA_t + \hat{\beta}_{2,t} \ln RD_t + \hat{\beta}_{3,t} \psi(X_t) \ln RD_t + \hat{\beta}_{4,t} \psi(X_t) + \varepsilon_t \qquad (2.6)$$

Since this transformation is additive without including the variable *R&D*, it does not have any impact on the *elasticity* of market value to current R&D expenditures, which is equal to:

$$\frac{\partial \ln V_t}{\partial \ln RD_t} = \hat{\beta}_{2,t} + \hat{\beta}_{3,t} \psi(X_t) \qquad (2.7)$$

The regression parameters $\hat{\beta}_{1,t}$, $\hat{\beta}_{2,t}$ and $\hat{\beta}_{4,t}$ in equation (2.6) are expected to be positive. The intercept $\hat{\beta}_{0,t}$ captures the valuation effect of variables not included in the equation, which may be positive, negative, or zero. The parameter measuring the indirect effect of R&D on market value can be also positive, negative, or zero.

2.3 Sample Selection Procedure and Data Description

The database for this study includes accounting and pricing data of companies belonging to the pharmaceutical industry as specified and reported by Datastream. This industry is particularly interesting because R&D investments are the lifeblood for the companies, i.e. one can expect that investments in R&D are one of the main sources of their future profits.

The data covers the period from 1990 to 2004. Firms are included in the sample for year t if data are available on market value, total assets and R&D expenditures for a financial year ending in year t. There are no restriction on the market capitalization of the companies in order to utilize the maximum possible sample in the following tests. Unobserved heterogeneity and selection bias is undoubtedly an issue, though most of the previous empirical studies do not deal with it. Moreover, the literature, which has adjusted for selectivity, conclude that Ordinary Least Square (OLS) results are probably not too seriously biased (see Bosworth and Rogers, 1998).

The sample consists of 148 US pharmaceutical companies with market capitalization ranging from USD 0.05 Mill. to USD 201755 Mill. (as of the end 2004). The broad range of market capitalization reflects the companies' diversity particularly with respect to their R&D investment activities. During the period from 1997 to 2004, some firms invest more than USD 2000 Mill. and others spending less than USD 0.011 Mill. (see Table 2.2).

Table 2.1: Summary statistics of R&D expenditures (1997-2000)

Thousand USD	1997	1998	1999	2000
Mean	149'025	130'024	120'969	123'235
Median	4'835	4'400	4'291	4'940
Maximum	1'905'000	2'140'000	2'279'000	2'776'000
Minimum	7	44	51	17
Std.Dev.	426'943	425'819	434'781	
Skewness	2.90	3.43	3.84	4.20
Kurtosis	9.94	13.48	16.53	19.97
Observations	78	101	121	134

Table 2.2: Summary statistics of R&D expenditures (2000-2004)

Thousand USD	2001	2002	2003	2004
Mean	135'698	151'165	160'843	185'509
Median	5'299	6'283	7'091	7'158
Maximum	4'435'000	4'847'000	5'176'000	7'070'000
Minimum	11	11	11	11
Std.Dev.	559'762	622'775	661'640	812'383
Skewness	5.19	5.20	5.30	6.04
Kurtosis	32.48	32.23	33.38	43.96
Observations	146	148	148	148

Since 1998, the mean and the median of R&D expenditures increases continuously. Though, the standard deviation, skewness and kurtosis increases as well. With the time, the wedge among the level of R&D activities deepen so that more companies become outliers. Figures 2.1 illustrates this result. Figure 2.2 shows the R&D distribution without far outliers. As one can easily see, the level of R&D expenditures for half of the companies is much lower (about USD 30 Mill.) than the level of R&D investments of the far outliers (more than USD 1000 Mill.).

Figure 2.1: R&D expenditures

The boxplot summarizes the distribution of R&D expenditures across companies for each year in the period 1995-2004. The data with the symbols '∘' and '∗' represent outliers.

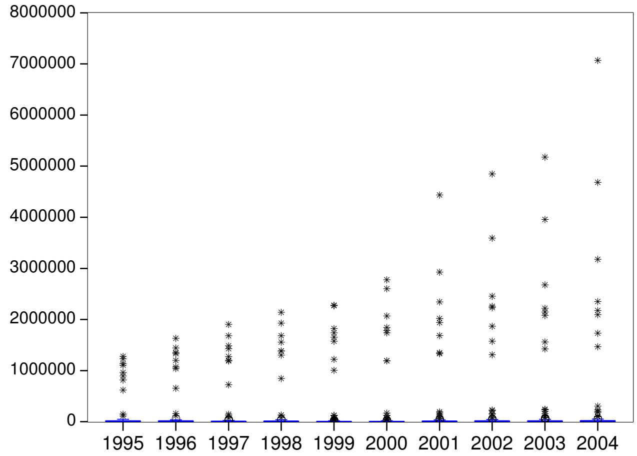
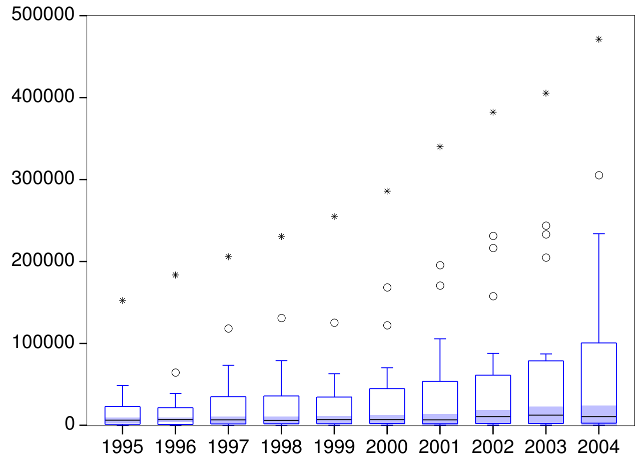


Figure 2.2: R&D expenditures without large outliers

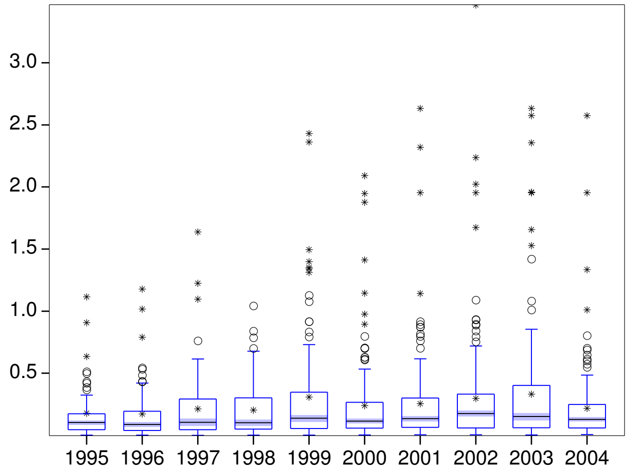
The box portion of the boxplot represents the first and third quartiles (middle 50 percent of the data). The median is depicted using a line through the center of the box, while the mean is drawn using the symbol '∗'.



One possible explanation for the large differences in the level of R&D expenditures across firms is that bigger companies usually have larger capacity to extend their R&D investments than smaller firms. To eliminate this effect in analyzing companies' heterogeneity, the R&D expenditures are normalized with the book value of total assets as reported by the companies at the end of each year. Figure 2.3 shows the distribution of the ratio R&D expenditures to total assets in a boxplot. The median is almost constant over time. There are still some outliers, however, they are smaller than the outliers in the R&D distribution (see Figure 2.1).

Figure 2.3: R&D expenditures to total assets (1995 - 2004)

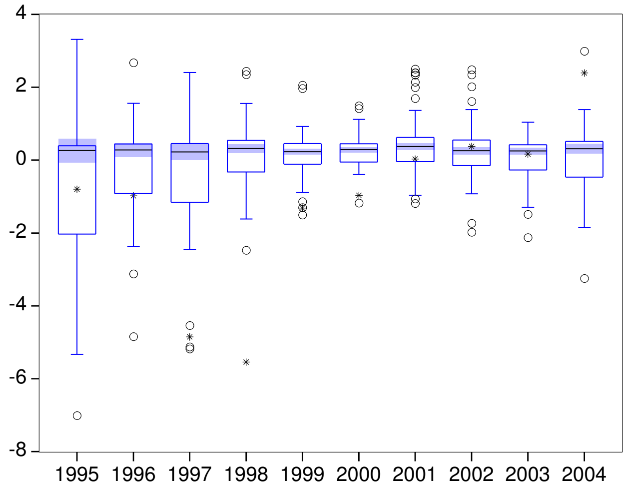
The boxplot summarizes the distribution of the ratio R&D expenditures to total assets across companies for each year in the period 1990-2004. The box portion of the boxplot represents the first and third quartiles (middle 50 percent of the data). The median is depicted using a line through the center of the box, while the mean is drawn using the symbol '$*$' within the box. The data with the symbols '$\circ$' and '$*$' are outliers.



The more interesting question for this study is the importance of firm earnings for the market value of R&D investments. To approach the question descriptively, Figure 2.4 plots the distribution of firms R&D expenditures relative to their reported earnings after taxes but before R&D expenditures.

Figure 2.4: R&D expenditures to earnings (1995 - 2004)

The boxplot summarizes the distribution of the ratio R&D expenditures to profits (after taxes and before R&D expenditures) across companies for each year in the period 1995-2004. The box portion of the boxplot represents the first and third quartiles (middle 50 percent of the data). The median is depicted using a line through the center of the box, while the mean is drawn using the symbol '$*$'. The data with the symbols '$\circ$' are outliers. Far outliers have been neglected.



Until 1998 and after 2003, the middle fifty percent of the companies continued to invest strongly in R&D although their reported profits have been negative in the current period. For the period between 1998 and 2003, the R&D expenditures of firms with positive and negative earnings do not differ substantially. Intuitively, firms deciding to invest more intensively in R&D in the face of negative earnings must be very confident in the prospects of their investments. The question is whether and to which extend do investors share the optimism of managers and reward their R&D investments.

2.4 Results

All tests are performed using (linear) Ordinary Least Squares (OLS) regression with multiple variables. The variables are defined as follows:

- V_t is a vector including the market capitalization of all firms at the end of the first quarter of year $t+1$.[7]
- TA_t a vector including the total assets as reported by the firms in the sample on the end of year t
- RD_t is a vector including the R&D expenditures of firms reported on the end of year t
- X_t is a vector including the after tax earnings before R&D expenditures (profits) as reported by the firms on the end of year t

To minimize the problem of heteroscedasticity, all variables are included with their logarithmic values. Additionally, the standard errors of the estimated coefficients are reported after adjusting for heteroscedasticity according to the White test. Autocorrelation is not an issue, since the model is specified for a cross-sectional sample with no lags over the time.

First, we estimate the market value of intangible capital as specified by equation (2.3). Then, we test the causal dependence between R&D expenditures and profits and confirm the adequacy of the specification in equation (2.6). The market value of R&D investments conditioned on the reported earnings is estimated with two different methods. The first splits the sample of firms in two groups in dependence of their earnings and estimate the market value of R&D expenditures of the firms within each group. The second approach estimates the market value of firms' R&D investments in dependence on the level of their reported profits directly by using the non-linear specification from equation (2.6).

2.4.1 The value of R&D investments as intangible capital

Adopting the notion that firm's value is determined by the capitalized value of its asset, the paper proceeds estimating the market value of firms' intangible assets

[7] The underlying assumption is that investors receive the accounting reports for the current year within the first quarter of the next one. Accounting information is reflected in market prices as soon as it is available.

approximated by their investments in R&D. Table 2.3 reports the estimated coefficients.

Table 2.3: The market value of intangible assets

$\ln V_t = \hat{\beta}_{0,t} + \hat{\beta}_{1,t} \ln RD_t + \varepsilon$

P values are reported under every coefficient in parentheses. The (centered) R^2 statistic explains the variation in $\ln V_t$ after fitting the constant. SSR is the sum of squared residuals. Standard errors are White-heteroscedasticity consistent.

$\log(V_t)$	$\hat{\beta}_{0,t}$	$\hat{\beta}_{1,t}$	R^2	SSR	N
2004	2.4314	1.0371	0.6248	463	148
	(0.000)	(0.000)			
2003	2.7376	1.0242	0.6443	394	142
	(0.000)	(0.000)			
2002	1.4594	1.0777	0.6108	486	140
	(0.030)	(0.000)			
2001	1.9090	1.1000	0.7530	244	136
	(0.109)	(0.000)			
2000	2.5110	1.0561	0.7028	274	130
	(0.000)	(0.000)			
1999	-4.5628	0.8907	0.6812	185	106
	(0.000)	(0.000)			
1998	3.7359	0.9526	0.6890	191	85
	(0.000)	(0.000)			
1997	5.5772	0.7878	0.6457	144	70
	(0.000)	(0.000)			
1996	4.9461	0.8516	0.7378	98	64
	(0.000)	(0.000)			

Overall, the market value elasticity with respect to R&D investments is significantly different from zero for every year. It is continuously increasing over time taking values from 0.8 to 1.1. The highest value is reached for the reporting year 2001, just before the overall industry price index drops down (see Figure 2.23). The estimated coefficients may be overstated due to the omission of the tangible assets as an explanatory variable because of its high correlation with the R&D investments. This issue is taken into account in the further analysis by including the reported profits after taxes, which can serve as a proxy for firms' size.

To get an intuition if there is more information on the elasticity parameter $\hat{\beta}_{1,t}$, the market value of R&D investments is conditioned on the reported earnings. The simplest way to get an idea on the relevance of earnings for the market value of R&D expenditures is to plot the variables. The sample of companies is divided in two groups: one containing firms reporting positive earnings ($X_t > 0$) and one containing firms reporting negative earnings in the current period ($X_t < 0$). The R&D expenditures and market values of the firms in both groups are plotted together for each of the reporting years. If investors value R&D projects in dependance on the current earnings, then the relationship between R&D investments and the market value would be different in both groups. Figures 2.5 to 2.10 visualizes the plausibility of this intuition for the sample of data from 1999 to 2004.

The plots show that the market value of R&D is not well determined by a simple linear function. In particular, the market value of firms with negative earnings do not always increase with the level of R&D spending. One part of the firms with negative earnings receives similar valuation for their R&D activities as firms reporting positive earnings, though another part of the firms with negative earnings do not. Thus, estimating the market value of R&D investments using a simple linear regression over the whole sample of firms without considering the importance of earnings characteristics would not be very precise if one aims to draw a conclusion on the market value of R&D investments. The accuracy of the results can be improved by conditioning the market value of R&D investments on the firms' earnings.

The simplest way to do this is to split the sample of firms in groups with different level of earnings.[8] The approach has the disadvantage that it reduces the number of observations within each group. Additionally, it does not provide any results on the sensitivity of the estimated coefficients with respect to different earnings levels. To overcome this problems, this study includes a third dimension in the analysis between market value and R&D investments describing the impact of earnings. The results are discussed in the following.

[8] Another possibility to take account for different earnings levels is suggested by Johnson and Pazderka (1993). They simply exclude companies reporting negative earnings and compare the results.

Figure 2.5: R&D market value (2004)

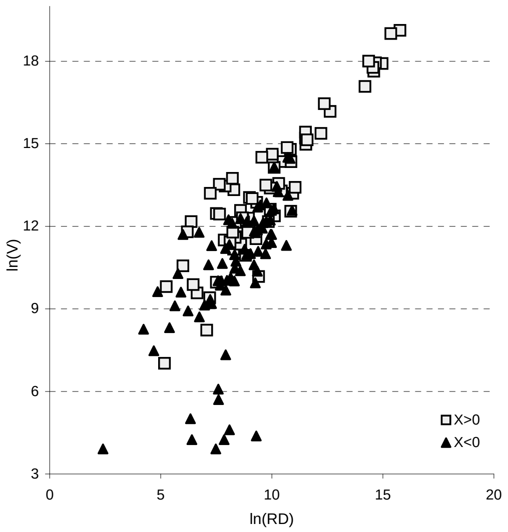


Figure 2.6: R&D market value (2003)

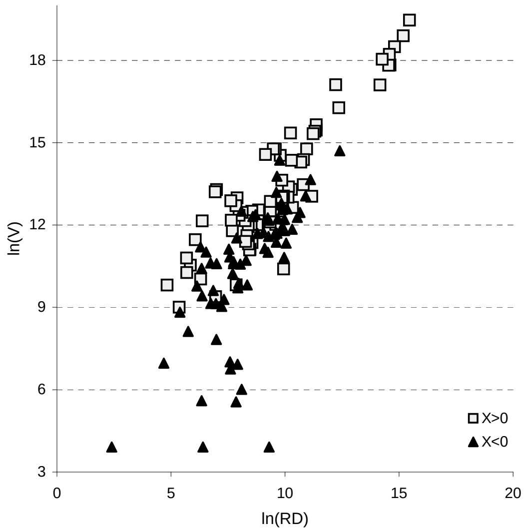


Figure 2.7: R&D market value (2002)

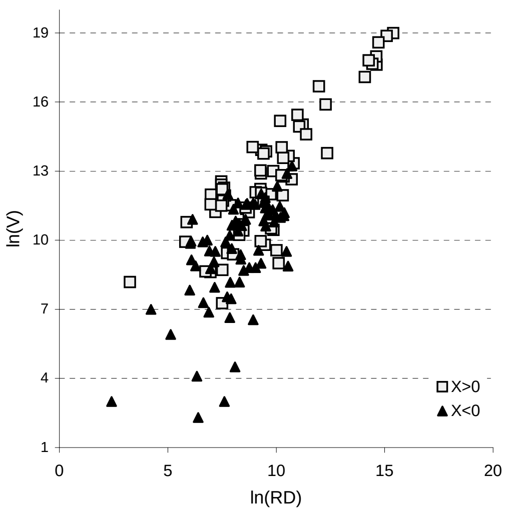


Figure 2.8: R&D market value (2001)

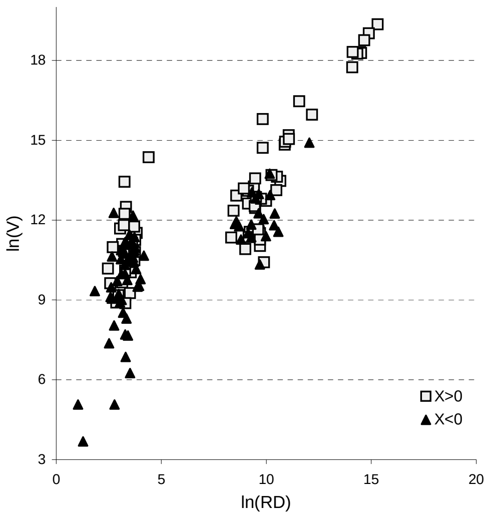


Figure 2.9: R&D market value (2000)

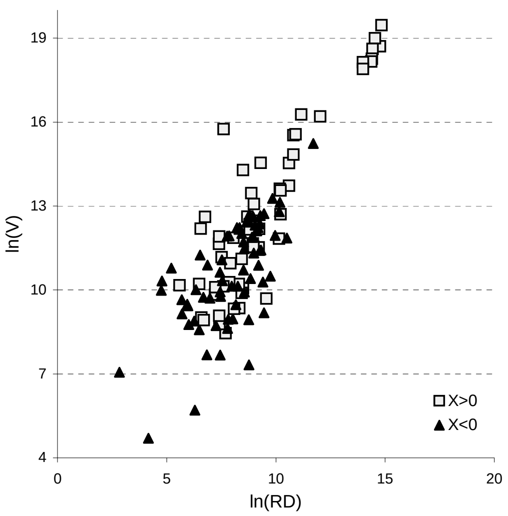
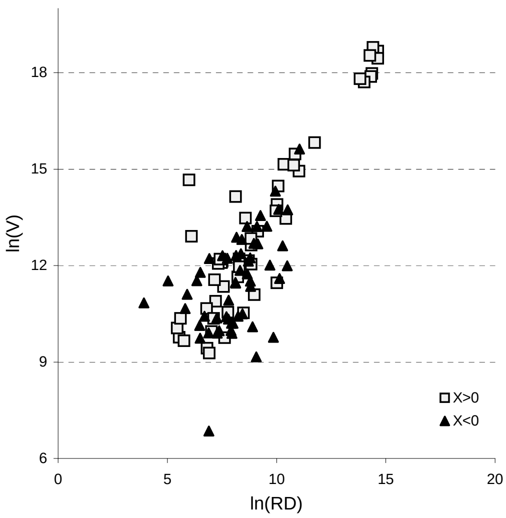


Figure 2.10: R&D market value (1999)



2.4.2 The causal dependence between R&D investments and profits

Before estimating how the market value of firms' R&D expenditures varies in dependence of the reported profits, we test whether the estimating equation (2.6) is specified correctly. In particular, the following tests aim to verify the current level of profits as variable reflecting the value of past R&D expenditures for the company. The tests are specified such as to estimate whether changes in past R&D investments cause changes in adjusted earnings as assumed in equation (2.6) or changes in past reported profits cause changes in current R&D expenditures. The results are reported in Table 2.4.

Table 2.4: The causal dependance between R&D investments and reported profits

(1) $\Delta RD_t = \hat{\alpha}_{0,t} + \hat{\alpha}_{1,t}\Delta RD_{t-1} + \hat{\alpha}_{2,t}\Delta RD_{t-2} + \hat{\beta}_{1,t}\Delta X_{t-1} + \hat{\beta}_{2,t}\Delta X_{t-2} + \varepsilon$
(2) $\Delta X_t = \hat{\alpha}_{0,t} + \hat{\alpha}_{1,t}\Delta X_{t-1} + \hat{\alpha}_{2,t}\Delta X_{t-2} + \hat{\beta}_{1,t}\Delta RD_{t-1} + \hat{\beta}_{2,t}\Delta RD_{t-2} + \varepsilon$

Equation (1) tests if changes in past earnings cause changes in R&D expenditures. Equation (2) tests if changes in past R&D expenditures cause changes in reported profits. The tests are performed using differences in the variables in order to insure that the variables included in the regressions are stationary.
P-values are reported under every coefficient in parentheses. The (centered) R^2 statistic explains the variation in ΔRD_t and ΔX_t after fitting the constant. Standard errors are White-heteroscedasticity consistent.

(1)	$\hat{\alpha}_{0,t}$	$\hat{\alpha}_{1,t}$	$\hat{\alpha}_{2,t}$	$\hat{\beta}_{1,t}$	$\hat{\beta}_{2,t}$	R^2	N
2004	-3032	0.7645	1.1068	-0.3431	0.2811	0.7845	132
	(0.426)	(0.207)	(0.001)	(0.216)	(0.057)		
2003	862	0.1714	-0.1643	0.0531	0.1364	0.8151	132
	(0.478)	(0.135)	(0.016)	(0.000)	(0.036)		
2002	4342	-0.1479	0.9667	0.1035	-0.0045	0.6673	119
	(0.084)	(0.561)	(0.034)	(0.547)	(0.814)		
2001	-3792	0.5308	2.2907	0.0354	-0.2313	0.7234	98
	(0.549)	(0.411)	(0.186)	(0.102)	(0.252)		
(2)							
2004	-8195	-1.4883	-2.1984	2.7742	5.7041	0.7672	132
	(0.574)	(0.002)	(0.002)	(0.422)	(0.001)		
2003	4662	0.4848	0.0138	1.4537	-0.6641	0.8153	132
	(0.442)	(0.000)	(0.960)	(0.007)	(0.093)		
2002	-16034	0.2196	-0.8882	2.6087	2.2173	0.8557	119
	(0.259)	(0.720)	(0.000)	(0.000)	(0.395)		
2001	1528	0.0273	0.3350	3.9078	-1.2559	0.8021	98
	(0.855)	(0.241)	(0.201)	(0.000)	(0.572)		

Comparing the significance of the coefficients $\hat{\beta}_{1,t}$ and $\hat{\beta}_{2,t}$ in the first equation, we can conclude that changes in past earnings do not cause significant changes in the current R&D expenditures except in year 2003.[9] For this year, changes in the past R&D expenditures cause also changes in current earnings so that the causal dependance between the variable is eliminated. The significance of the coefficients $\hat{\beta}_{1,t}$ and $\hat{\beta}_{2,t}$ in the second equation suggests that lagged changes in R&D expenditures cause changes in current reported profits. This causal dependance is in line

[9] This result is valid if one requires that the coefficients are significant different from zero at the 5% level.

with the assumption that the value of past R&D expenditures can be captured by their impact on reported profits as formulated in equation (2.6).

2.4.3 The value of R&D investments in firms with positive and negative profits

The results from the first section suggest that firms investing in R&D receive higher market valuation on average. Though, not every firm can be successful in its R&D activities and do best all the time. Therefore, we expect to see that smart investors differentiate between firms investing in R&D by considering their current profitability as reflected in the published earnings after taxes. The intuition behind this idea is visualized in Figures 2.5 to 2.10. This section reports the results of an empirical test estimating the significance of the intuition.

The test is performed by simply splitting the sample of firms in two groups: one including companies reporting positive earnings (Group A) and another one including firms reporting negative earnings in the current period (Group B). An indicator function $\mathbb{I}$ determines to which group a firm belongs. The market value of R&D expenditures is then estimated separately for each group. Table 2.5 summarizes the results.

Table 2.5: The market value of R&D of firms with different reported profits

(Group A): $\ln V_t = \hat{\beta}_{0,t} + \hat{\beta}_{1,t} \ln RD_t \mathbb{I}_{X_t>0} + \varepsilon_t$
(Group B): $\ln V_t = \hat{\beta}_{0,t} + \hat{\beta}_{1,t} \ln RD_t \mathbb{I}_{X_t<0} + \varepsilon_t$
where $\mathbb{I}_{X_t>0} = \begin{cases} 1 \text{ for } X_t > 0 \\ 0 \text{ for } X_t < 0 \end{cases}$ and $\mathbb{I}_{X_t<0} = \begin{cases} 1 \text{ for } X_t < 0 \\ 0 \text{ for } X_t > 0 \end{cases}$

P-values are reported under every coefficient in parentheses. The (centered) R^2 statistic explains the variation in $\log V_t$ after fitting the constant. Standard errors are White-heteroscedasticity consistent. The total assets are excluded from the estimation equation since they are highly correlated with the level of R&D investments.

Group A	$\hat{\beta}_{0,t}$	$\hat{\beta}_{1,t}$	R^2	N	Group B	$\hat{\beta}_{0,t}$	$\hat{\beta}_{1,t}$	R^2	N
2004	4.3692	0.9140	0.8206	71		2.5962	0.9345	0.3888	77
	(0.000)	(0.000)				(0.015)	(0.000)		
2003	4.8828	0.8824	0.8173	73		2.2711	0.9800	0.4693	69
	(0.000)	(0.000)				(0.012)	(0.000)		
2002	3.4256	0.9591	0.7210	68		2.1729	0.8958	0.3762	72
	(0.000)	(0.000)				(0.058)	(0.000)		
2001	8.4592	0.5568	0.6685	67		8.0289	0.4500	0.4558	69
	(0.000)	(0.000)				(0.000)	(0.000)		
2000	2.3358	1.1136	0.7845	57		4.3845	0.7837	0.4584	72
	(0.001)	(0.000)				(0.000)	(0.000)		
1999	4.4852	0.9414	0.8284	50		7.0608	0.5420	0.2625	55
	(0.000)	(0.000)				(0.000)	(0.001)		
1998	4.3358	0.9509	0.8128	51		5.4772	0.6351	0.3324	34
	(0.000)	(0.000)				(0.000)	(0.000)		

Until 2002, firms reporting positive earnings receive a higher market valuation for their R&D activities than firms reporting negative earnings. After 2001, the difference in the coefficients $\hat{\beta}_{1,t}$ is not significant at the 5% level.

2.4.4 The value of R&D investments conditioned on the level of firms' profits

To take a closer look on the significance of the relationship between the market value of R&D investments and firms earnings a non-linear functional form describing the sensitivity of market value to R&D investments in dependence on small changes in firms' profits is introduced. The advantage of this approach compared to the previous one is that the estimation does not separate firms imposing assumptions on the criteria that might be relevant for investors while evaluating firms' R&D activities in the context of their profits. Instead, these criteria are the output of an estimation searching for the best fit with the data. The results are reported in Table 2.6.

All coefficients besides of the intercept are significant different form zero at the 5% level. The R^2 statistic is in each year better than the statistic in the simple case estimating the market value of R&D investments without conditioning on firms' earnings (see Table 2.3). Moreover, the sum of squared residuals is in each year lower. If one neglects companies with negative profits, the test does not always fit better the data. Though, for this sample, this would mean to exclude approximately one half of the companies each year (see the last column in Table 2.5).

Table 2.6: The market value of R&D conditioned on firms' reported profits

$\ln V_t = \hat{\beta}_{0,t} + \hat{\beta}_{1,t} \ln RD_t + \hat{\beta}_{2,t} \frac{1}{1+e^{-a-bX_t}} + \hat{\beta}_{3,t} \frac{1}{1+e^{-a-bX_t}} \ln RD_t + \varepsilon_t$

P-values are reported under every coefficient in parentheses. The (centered) R^2 statistic explains the variation in $\log V_t$ after fitting the constant. Standard errors are White-heteroscedasticity consistent. SSR is the sum of squared residuals. The coefficients a and b solve an optimization problem minimizing the p-value of the t-statistic. Clearly, these values are not unique. It is possible that there are other values for a and b, for which the relationship between the variables is significant as well.

$\log V_t$	$\hat{\beta}_{0,t}$	$\hat{\beta}_{1,t}$	$\hat{\beta}_{2,t}$	$\hat{\beta}_{3,t}$	a	b	R^2	SSR	N
2004	2.8155	0.9092	5.9923	-0.3206	2	-0.1^4	0.6875	339	148
	(0.005)	(0.000)	(0.001)	(0.041)					
2003	-2.7507	1.3262	9.7669	-0.5940	-0.5	-0.1^4	0.7588	266	142
	(0.215)	(0.000)	(0.001)	(0.025)					
2002	-11.845	1.5590	24.9899	-1.2452	-0.5	-0.1^5	0.8206	369	140
	(0.003)	(0.000)	(0.000)	(0.006)					
2001	-1.1326	1.1244	12.5293	-0.6468	0.5	-0.1^5	0.7969	200	136
	(0.522)	(0.000)	(0.001)	(0.022)					
2000	1.3066	0.9570	18.6557	-1.0667	1.5	-0.1^5	0.7634	216	128
	(0.270)	(0.000)	(0.000)	(0.003)					
1999	3.9806	0.7774	22.3340	-1.3429	2	-0.1^5	0.7385	151	106
	(0.000)	(0.000)	(0.006)	(0.012)					
1998	4.9831	0.6583	38.0382	-2.3825	3	-0.1^5	0.7747	138	85
	(0.000)	(0.000)	(0.007)	(0.014)					
1997	6.9526	0.4355	30.9268	-1.8288	2.5	-0.1^5	0.8075	77	69
	(0.000)	(0.008)	(0.012)	(0.031)					

The best way to interpret these results is to show the relationship between the market value of the firms, its R&D investments and adjusted earning in a three-dimensional plot (see Figure 2.11 to 2.22). The level of R&D expenditures is plotted on the x-axis, reported profits are on the y-axis, and the vertical axis measures the market value of the firms. For each year there are two plots, one (on the left side) representing the estimated relationship for 95% of the observations and one (on the right side) with a smaller scale representing 75% (3. Quartile) of the firms.

In the following discussion we first consider the importance of reported profits (y-axis) for the market value of R&D expenditures. Then, we focus on firms with positive earnings and analyze how the market value of the firm changes when the firm boost its R&D investments. Finally, the results are interpreted for the smaller sample of firms including 75% of the observations.

For 95% of the firms (plots on the left side of the pages), the level of reported profits has a significant impact on the market value of their R&D expenditures. The effect is observed particularly for companies reporting positive profits. In general, the market value of these companies increases with the level of their R&D investments. Though, the effect changes over time. With the strong increase in R&D expenditures in 1998, even firms reporting negative profits receive a higher market valuation for their R&D expenditures (see Figure 2.21). This effect mitigates over time and profits become more and more important for investors valuing the R&D activities of the firms. For the period from 2000 to 2002, the market value of R&D investments increases smoothly with the reported profits. Though, the marginal market return on R&D investments by firms in particular with the highest positive profits is decreasing. Since 2003, the marginal return of R&D investing by all profitable firms becomes constant.

To get an intuition on why the relative importance of profits changes over time when investors estimate the market value of firms' R&D one can look for example at the industry price index.

There are three important market phases for the current discussion. The first one is the year 2000. In this year the market value of the pharmaceutical companies worldwide increased strongly. The second phase is the period from the first quarter 2001 to the first quarter 2003. During these two years, pharmaceutical companies lost a significant part of their market valuation. The first signs of a slight recovery can be seen in the last phase, which lasts from the first quarter 2003 to the first quarter 2005.

The strong increase of market valuation during the first phase reduces the risk premia required by investors so that the net present value of riskier projects particularly those run by firms with negative projects increases. As a result, the sensitivity of the market value of R&D investments to the current reported profits decreases (see Figure 2.21). With the sharp decrease in the market valuation of the companies in the first quarter 2001, the risk premia required by investors for holding shares of companies with negative profits increases, so that the net present value of their R&D projects decreases (see Figure 2.19). During the second phase, the R&D projects of firms with negative are discounted stronger than the R&D investments of firms with positive profits according to the higher risk premia required by investors (see Figures 2.17 and 2.15). During the last phase, the level of reported profits do not have any impact on the market value of R&D expenditures as long as the profits are positive and the market value of the firm increases proportionally with firms' R&D expenditures (see Figures 2.13 and 2.11).

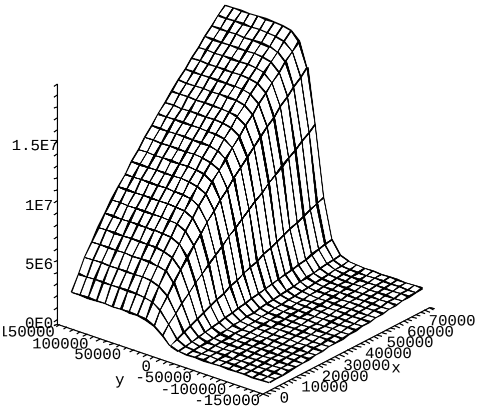


Figure 2.11: ConditionalR&D value, 2004

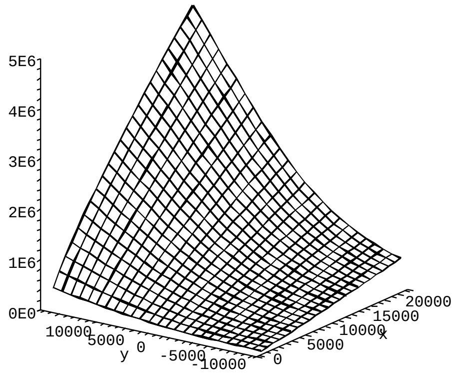


Figure 2.12: Conditional R&D value, 2004,3rdQ

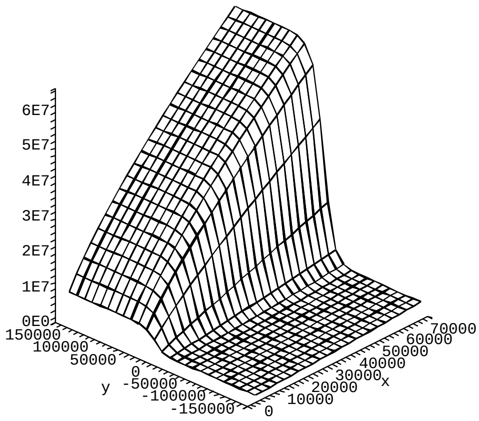


Figure 2.13: ConditionalR&D value, 2003

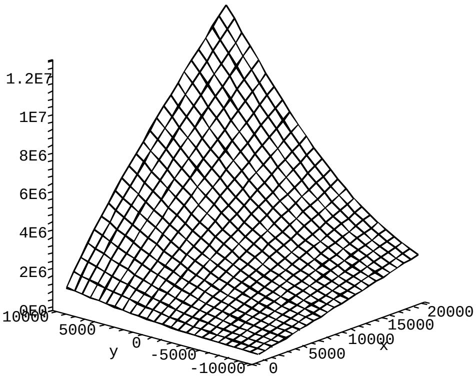


Figure 2.14: Conditional R&D value, 2003,3rdQ

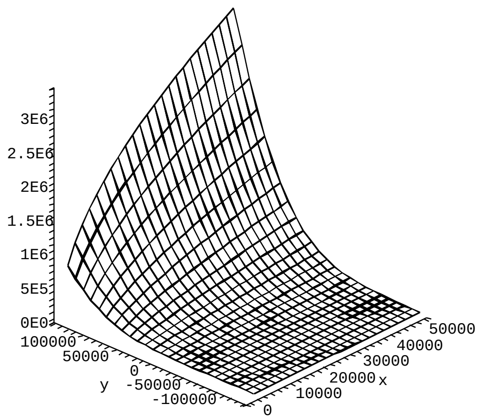


Figure 2.15: ConditionalR&D value, 2002

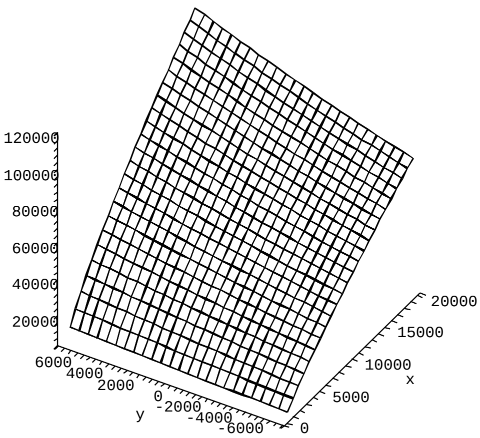


Figure 2.16: Conditional R&D value, 2002,3rdQ

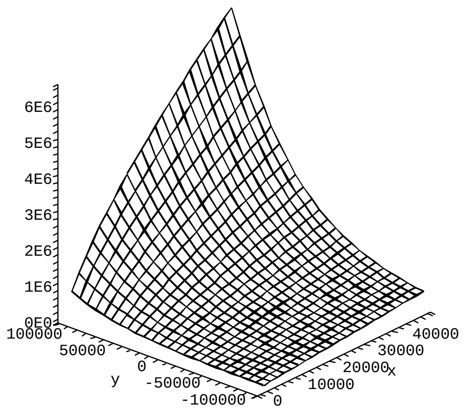


Figure 2.17: ConditionalR&D value, 2001

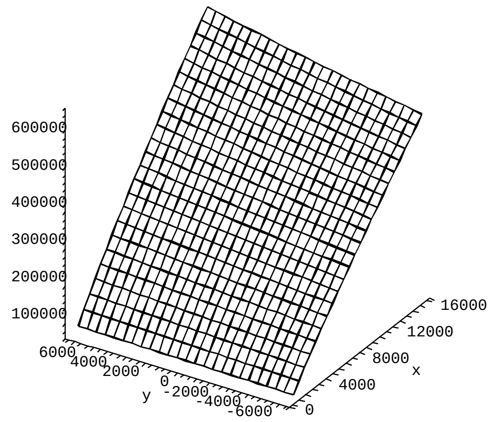


Figure 2.18: Conditional R&D value, 2001,3rdQ

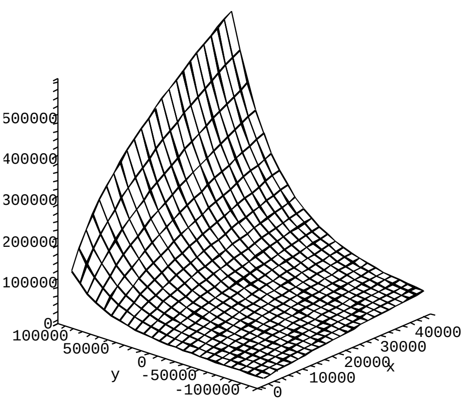


Figure 2.19: ConditionalR&D value, 2000

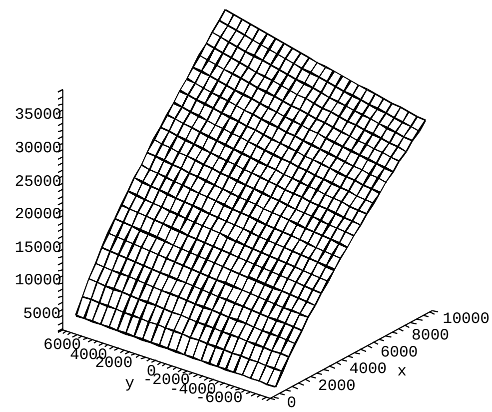


Figure 2.20: Conditional R&D value, 2000,3rdQ

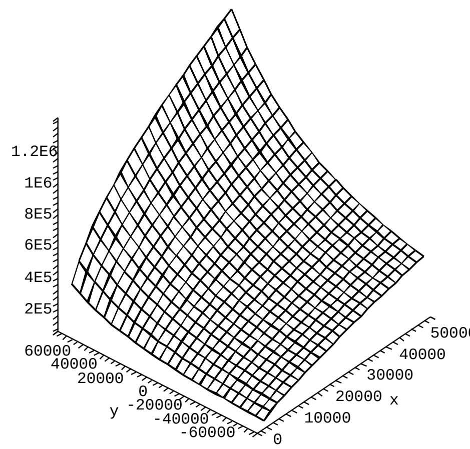


Figure 2.21: ConditionalR&D value, 1999

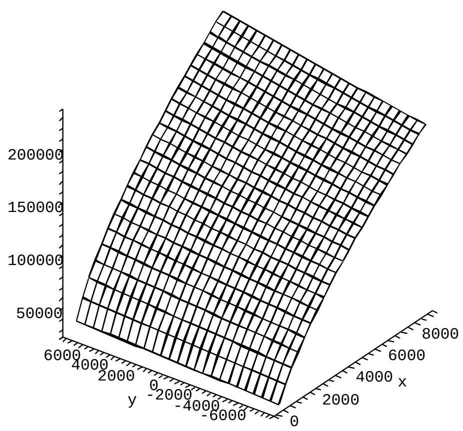
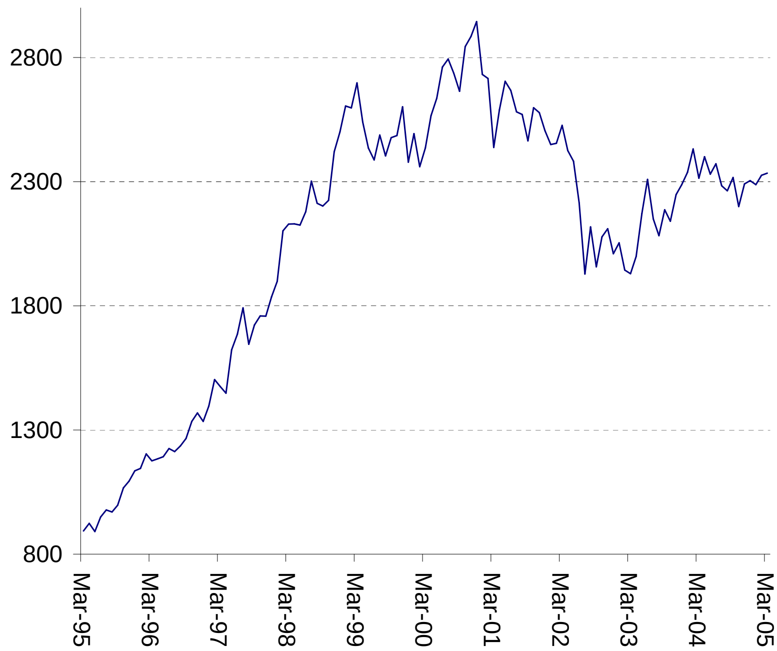


Figure 2.22: Conditional R&D value, 1999,3rdQ

Figure 2.23: Datastream World Pharmaceutical Index (1995 - 2005)



The importance of negative profits for the market value of R&D investment is better observable for firms with R&D investments and profits within the third quartile (75% of the observations). Investors analyzing firms with low levels of R&D investments do not condition the value of these investments on the firms' reported profits. The stronger firms decide to invest in R&D, the more important are the reported profits for the market value of their R&D investments. With the recovery in the overall market valuation in the last phase, the R&D projects of firms with positive profits gain more in value than the projects of firms with negative profits (see Figures 2.14 and 2.12). That is, firms with positive profits have a stronger advantage from the reduction in the overall risk premia than firms with negative profits.

Overall, in periods of sharp increase of the overall market valuation, the R&D projects of firms with negative profits have a stronger advantage from the decrease in the risk premia required by investors. When the risk premia increases, the net present value of riskier R&D projects run by firms with negative profits decreases. A slight recovery in the overall market valuation, i.e. a lower risk premia, increases the net present value of R&D projects in particular for firms with positive profits. As long as the firm report profits over the threshold its market value increases proportionally to its R&D investments.

2.5 Discussion

Why should the value of R&D investments as reflected in the market value of the firm increase with its profits? One possible explanation is related to the financial restrictions of the firm. The profits earned by the company are necessary to finance R&D investments. For most well-established corporations, R&D spending is not strongly dependent upon internal cash flow, but pharmaceutical companies are probably an exception (see Himmelberg and Petersen, 1994). Thus, the higher the profits, the less restricted is the company with respect to covering further investments, which might be required in the following periods. The value of this flexibility is embodied in the value of current R&D investments conditioned on firm's profits as reflected in the market value of the company.

Another explanation for the positive relationship between firm's profits and the value of its R&D investments is related to the skewness of firms' profits - only a minority of new products lead to exceptional profits, most of the products return less than the capitalized cost of their R&D investments (see Grabowski and Vernon[26]). The products contribution to profits depends not only on the size and duration of the investments but also on firm's abilities to manage them efficiently. In the pharmaceutical industry, investments in R&D are the lifeblood of the companies. Additionally, the product development usually requires continuous investments over several years. From this perspective, firm's current profits can be seen as indicators for the profitability of past R&D investments, i.e. firm's abilities to manage R&D projects efficiently. Conditioning current R&D investments on this information, firms with higher profits indicating a better implementation of past R&D projects are expected to receive a higher valuation for their current R&D activities. Overall, positive profits may relax the capital constraint of the company but also signal firm's abilities to manage R&D projects efficiently.

The effect of negative profits on the market value of firm's R&D investments is more puzzling. Intuitively, negative profits are not necessary bad since they force managers to be very careful when selecting further R&D projects although past R&D expenditures still do not return earnings. On the other hand, early stage firms with few products in development may continue to invest although the results are less than promising just because managers are reluctant to return funds to shareholders. Additionally, if managers care about losses as suggested by Kahneman and Tversky, they would probably feel comfortable gambling-to-get-back-to-even. This increases also the probability for a default. The larger the R&D spending when profits are negative the higher is the default risk, the more likely is it that investors focus stronger on the probability that the firm can not sustain the planed R&D growth and have to bankrupt. Overall, managerial decision to invest in R&D despite negative profits may reflect managerial optimism in the prospect of the current projects. Though, from investors' perspective managerial incentives to take more risks and continue poor projects "throwing good money after bad" appears to be stronger, so that firms reporting negative profits receive a lower market value for their R&D investments than firms reporting positive profits.

What are the implications for the managers' reporting? If investors evaluate R&D projects differently in dependence on the level of the reported profits, then managers have incentives to manage the reported numbers in order to receive a higher market valuation for their R&D investments. If the earnings manipulation remains uncovered by investors, managers' manipulation would follow the R&D investment cycle, i.e. in periods of high (low) R&D investments, managers would manipulate reported profits up (down). The next chapter proves the existence of such an equilibrium. The empirical validation of this hypothesis is a subject of future research.

2.6 Conclusion

In modern economics many firms invest strongly in intangible assets in particular through R&D. This paper addresses the question whether firms' reported earnings are relevant for the market value of their R&D investments. The empirical evidence reported in this study confirms that there is a certain direct link between R&D investments and the market value of the firm as reported in previous studies. In particular, the study shows that the effect depends on the current profits of the companies. Firms reporting positive profits receive a higher market valuation for their R&D activities than firms reporting negative profits. This effect is significant and persistent over time. Though, in different market phases the investors' sensitivity to shifts in R&D investments and profits changes over the business cycle.

The results are highly significant for the sample of firms in the US pharmaceutical industry. Further tests with firms in other knowledge-driven industries (e.g. biotechnology, semiconductors) can provide insights to the question whether the observed effects are common for firms in R&D-intensive sectors.

Chapter 3

The Earnings Game with Behavioral Investors

3.1 Introduction

Each quarter, the attention of the investors' community is drawn to the earnings numbers reported by public companies. However, these numbers themselves are of much less relevance than their value relative to certain benchmarks.

The main benchmarks investors use are the previous earnings (Burg-stahler and Dichev, 1997) and the analysts' consensus forecast (Degeorge, Patel, and Zeckhauser, 1999; Brown, 2001; Matsumoto, 1999; Freeman and Tse, 1992). Compelling empirical evidence suggests that firms falling short of the benchmarks are priced at a discount, which is larger in absolute terms than the premium the firms get when they report earnings above the benchmark (Kasznik and McNichols, 2002; Bartov, Givoly and Hayn, 2002; Skinner and Sloan, 2002). Ultimately, executives seem also to believe that hitting earnings benchmarks strengthens their creditability, helps increasing their companies' stock price (Graham, Harvey, and Rajgopal, 2005) as well as their compensation (Matsunaga and Park, 2001).

Given the empirical evidence on the relevance of benchmarks, we analyze the question how the asymmetric price response to meeting and falling short of the benchmarks affects the reporting decision of the managers. Assuming that the benchmarks are exogenously given, previous studies conclude that the observed patterns in the managers' reporting are due to earnings management. However, it is not clear whether managers' incentives to manipulate earnings remain unchanged when this assumption does not hold. In particular, it is ambiguous whether and how managers would manipulate earnings when the analysts behave strategically when playing the earnings game.

To answer this question, we propose a three–period model with a manager, analysts and investors endowed with behavioral preferences. We show that when the manager and the analysts behave strategically, the manager's incentives to manipulate earnings change as a response to the investors' preferences defining the market conditions, the manager's compensation package and the manager's guidance provided to analysts. In particular, our results suggest that given the asymmetric investors' reaction to earnings surprises, the manager strongly prefers to manipulate earnings than to report truthfully independently of her compensation package. If the manager is roughly indifferent between selling shares in the current or later periods, she manipulates the earnings in order to meet the analysts forecasts. In this equilibrium rational investors are systematically fooled. In all other cases, investors are able to reverse the manager's manipulation so that the reporting decision of the manager depends strictly on her time preferences. Assuming that manager's preferences are equally distributed in the economy, we also derive conclusions on how the absolute level of manipulation in the economy changes with the investors' preferences, the manager's compensation and the earnings guidance she may provide to analysts. Our results suggest that whatever the manager's compensation there will be less manipulation in absolute terms when investors have behavioral preferences. The absolute level of manipulation may also decrease if the manager are compensated with stock options instead of shares independently on the investor's preferences. However, if investors are non–behavioral and the managers holding stock options provide earnings guidance, i.e anticipates the action of the analysts to their earnings reports, the absolute manipulation level in the economy would increase compared to the no–guidance case.

In our framework, the manager's decision to manipulate earnings is a matter of an inter–temporal substitution. The manager may shift revenues from one year to another at costs determined by the investors and in particular by their preferences with respect to earnings reports.

Previous research on the question why managers manipulate earnings reports provides other explanations. Using the idea that earnings management is costly, Chaney and Lewis (1994) show that managers manipulate earnings to signal their ability to generate value. By smoothing reporting earnings around the "expected" earnings report, high-value managers can increase the probability that investors identify their ability of generating value correctly. On the other hand, if low-value managers realize that the costs of misreporting exceeds the benefits of being identified as a high-value firm, then the earnings signals of the firms can be perfectly informative in equilibrium. Instead of manipulating earnings in order to make investors believe the firm is more valuable, Trueman and Titman (1989) show that firms manipulate earnings because they want investors to perceive the firm as less risky. According to their model, lower-quality firms mimic higher-quality firms by smoothing the earnings reports, which lowers the investors' assessment of the probability of bankruptcy. Managers may also manipulate earnings because investors are unable to observe the manager's objectives and adjust to the bias added to the earnings reports. The manager's optimal level of manipulation is then determined by the trade-off between some costs of earnings management and the benefit of higher stock price resulting from higher reported earnings (see Fischer and Verrecchia, 2000). This idea is also used by Guttman, Kadan and Kandel (2004) in order to explain why earnings reports are discontinuous around some thresholds. By hiding some of their private information in a pooled report managers with different economic earnings are able to increase their payoff by reducing the costs of earnings manipulation. Further, firm's earnings management choice may also be driven by the choices made by its rivals. If a firm is compared by investors and creditors with other firms in the same industry, it would manage its earnings simply because it expect its rivals to do so (see Bagnoli and Watts, 2000). Finally, Stein (1989) suggests that earnings management occurs if managers are myopic. The conclusion rests basically on the assumption that investors form expectations based on the noise in the earnings signals but not on the level of earnings relative to certain thresholds.

The importance of thresholds is, however, emphasized in several empirical studies. Barth, Elliott, and Finn (1999) find that firms that report continuously growing earnings are priced at a premium to other firms and the premium increases with the length of the string. Myers and Skinner (2001) find that managers of such firms usually have relatively large amount of personal wealth invested in the company providing them with incentives to extend the earnings string making accounting choices that avoid reporting adverse earnings.

The relevance of the consensus forecast is highlighted by other studies. Kasznik and McNichols (2002) find that firms which meet expectations receive a higher market value than firms that fail to meet the expectations. Although they additionally conjecture that firms consistently meeting the consensus do so through strong earnings, they cannot exclude the possibility that firms could meet expectations by earnings manipulation and investors may fail to anticipate this. In a recent study, Degeorge, Patel and Zeckhauser (2006) investigate the price response to earnings reports meeting the consensus forecast over time. They find that firms meeting or exceeding earnings thresholds experience economically and statistically significant excess returns, which are particularly high in a bull market. Their results motivate them to conjecture that investors seem to view earnings threshold attainment as an important indicator of the health of the company, which encourage the managers to manipulate earnings. To test the benefits from earnings manipulation, Bartov, Givoly and Hayn (2002) examine the manner by which earnings management contributes to the premium that firms receive when they meet or beet earnings expectations. They confirm that firms receive a premium if they manage to meet or beet the consensus forecast and show, in addition, that investors are capable to discern the effect of earnings management on the earnings surprise and discount the resulting surprise, but the extent of this discount is small and not economically significant. Further, Skinner and Sloan (2002) show that the stock price response to falling short of the analysts expectations is disproportionately large for growth stocks.

Our research presented in this part of the thesis contributes the literature on earning management in several ways. First, we extent the theoretical literature by studying a three-period strategic game between a manager and the analysts rather than a one–shot disclosure choice of different firms involved in a signaling game with other competitors. That is, instead of assuming that there are high- and low-value firms manipulating earnings to pool their reports, we use the empirical evidence that investors value earnings reports with respect to thresholds to study the manager's manipulation incentives in a setting where the threshold is not exogenously given but defined by analysts behaving strategically. Thus, the focus of our study is not the managers' incentives to manipulate earnings when playing a game with other managers endowed with private information regarding their value as in the signaling literature. Instead we focus on the manager's incentives to manipulate earnings when the manager is involved in a strategic game with the analysts. Whereas the signaling literature assumes that the differences in the managers' type motivating earnings manipulation are exogenously given, we specify the analysts' response representing a threshold for the value of earnings reports endogenously.

Second, by studying manager's manipulation incentives when her payoff is defined by behavioral investors we contribute to the general discussion on the economic relevance of investors' preferences for earnings reports that are at or above the target defined by the analysts. Some empirical studies have already hypothesized that this investors' attitude motivate managers to manipulate earnings in order to meet the targets (see for example Degeorge, Patel, Zeckhauser, 1999). However, they did not explicitly considered the possibility that analysts may be fairly aware of their role as target setters, which again may change the manager's motivation to manipulate earnings.

Finally, our analysis contribute to the literature dealing with the definition of regulatory standards. By studying a simple economy where the managers' time preferences are equally distributed, we derive conclusions on how the absolute level of manipulation in that economy change with the investors' preferences, the managers' compensation package and the earnings guidance provided by managers to analysts.

This chapter is organized as follows. The next section describes the information structure of the game and the decision processes of the manager, the investors and the analysts. Section 3 defines the players of the game, their strategy sets and payoffs. It also defines the game equilibria. The players' strategies in equilibrium are studied in section 4. The analysis is structured in three parts. The first part considers the manager's incentives to manipulate earnings when the manager holds stock options and play the earnings game with behavioral and non–behavioral investors. The second part studies the managers' incentives to manipulate earnings, when they hold stock options instead of shares and play the earnings game with behavioral and non–behavioral investors. The third part analyzes how the manager decides on earnings manipulation when she provides earnings guidance to analysts. The main results as well as the impact of the market conditions, the manager's compensation and the manager's guidance on the absolute level of manipulation in the economy are summarized in section 5.

3.2 Information Structure and Decision Timing

We consider a three–period economy with one firm, analysts and a large number of investors. The firm is controlled by a manager. The information structure and the decision order of the agents in the economy are summarized as follows.

$t-1$	t	$t+1$
1. Analysts: F_t	1. Nature: x_t	1. Nature: x_{t+1}
	2. Manager: D_t	2. Manager: D_{t+1}
	3. Analysts: F_{t+1}	3. Investors: P_{t+1}, C_{t+1}
	4. Investors: P_t, C_t	

In period $t-1$, the analysts make forecasts on the earnings that will be reported by the manager in period t. The average of their forecasts in this period, i.e. the consensus forecast, is denoted by F_t.

At the beginning of period t, nature chooses which state of "true" earnings $x_t \in \{\underline{x}, \overline{x}\}$ realizes. All agents in the economy agree that the probability for observing $\overline{x}$ is p and the probability for observing $\underline{x}$ is respectively $1-p$. The "true" earnings are also assumed to be common knowledge, so that the firm's outsiders know the moments of the "true" earnings distribution. However, only the manager is able to observe which state of "true" earnings realizes in each period.

After observing x_t and F_t, the manager decides whether and how to manipulate earnings. In dependence on the state of "true" earnings and the manipulation decision of the manager, earnings reports in period t are $D_t = (\overline{D}_t, \underline{D}_t)$, where $\overline{D}_t = \overline{x}_t + \overline{m}$ and $\underline{D}_t = \underline{x}_t + \underline{m}$, with $\overline{m}$ as the manipulation decision of the manager given that $x_t = \overline{x}$, and $\underline{m}$ as the manipulation decision of the manager given that $x_t = \underline{x}$. We assume that the manager's discretion to manipulate earnings is limited by certain bounds, i.e. $\overline{m}, \underline{m} \in [m_{min}, m_{max}]$, where $m_{max} > 0$ and $m_{min} < 0$. That is, the manager is allowed to inflate or deflate earnings but her report cannot be too far away from the "true" earnings, otherwise the auditors would not accept it. For simplicity we assume that $|m_{max}| = |m_{min}|$. The bounds in our setting are common knowledge.

The analysts use the manager's report D_t to update their beliefs regarding the next period earnings the manager will be able to report. The consensus forecast is captured by F_{t+1}. Depending on the observed earnings in period t, i.e. $\overline{D}_t$ or $\underline{D}_t$, the consensus forecast for the earnings reported in $t+1$ are denoted by $\overline{F}_{t+1}$ respectively $\underline{F}_{t+1}$. The analysts communicate their updated expectations to investors and they respond by adjusting the price of the firm's shares $P_t = (\overline{P}_t, \underline{P}_t)$, which returns the value of the firm's stock options $C_t = (\overline{C}_t, \underline{C}_t)$. In our notation, $\overline{P}_t$ ($\underline{P}_t$) is the price of the firm's shares and $\overline{C}_t$ ($\underline{C}_t$) captures the value of the firm's stock options in period t given that $x_t = \overline{x}$ ($x_t = \underline{x}$) and $D_t = \overline{D}_t$ ($D_t = \underline{D}_t$).

In the last period, nature draws the "true" earnings $x_{t+1} \in \{\overline{x}, \underline{x}\}$. In this period, we assume that the manager does not make any decisions. His reporting is defined by the "true" earnings realizing in this period and the manipulation decision taken one period before. This is consistent with accounting standards such as GAAP requiring that any discretionary element in reported earnings must be eventually reversed over time so that at the end of the game, there is no manipulation remained in the economy and the accumulated reported earnings reported are equal to the accumulated "true" earnings. We operationalize this institutional requirement through a GAAP constraint requiring that the bias added in the period t is reversed in the next one. The earnings reports in the last period are then $D_{t+1} = (\overline{x} - \overline{m}, \overline{x} - \underline{m}, \underline{x} - \overline{m}, \underline{x} - \overline{m})$ with $x_{t+1} \in \{\overline{x}, \underline{x}\}$.

Given the reported earnings $D_{t+1} = (\overline{x} - \overline{m}, \overline{x} - \underline{m}, \underline{x} - \overline{m}, \underline{x} - \overline{m})$ and the consensus forecast $F_{t+1} = (\overline{F}_{t+1}, \underline{F}_{t+1})$, the investors determine the price of the company's shares $P_{t+1} = (\overline{P}_{t+1}, \underline{P}_{t+1})$ where $\overline{P}_{t+1}$ is the price of firm's shares given that $x_t = \overline{x}$ respectively $D_t = \overline{D}_t$ and $\underline{P}_{t+1}$ is the price of firm's shares given that $x_t = \underline{x}$ respectively $D_t = \underline{D}_t$.

The players' actions in each state are summarized in the following figure.

$$
F_t \begin{cases}
\xrightarrow{p} \overline{x},\, \overline{D}_t = \overline{x} + \overline{m},\, \overline{P}_t,\, \overline{C}_t,\, \overline{F}_{t+1} \begin{cases} \xrightarrow{p} \overline{x},\, \overline{D}_{t+1} = \overline{x} - \overline{m},\, \overline{P}_{t+1},\, \overline{C}_{t+1} \\ \xrightarrow{1-p} \underline{x},\, \overline{D}_{t+1} = \underline{x} - \overline{m},\, \overline{P}_{t+1},\, \overline{C}_{t+1} \end{cases} \\
\xrightarrow{1-p} \underline{x},\, \underline{D}_t = \underline{x}_t + \underline{m},\, \underline{P}_t,\, \underline{C}_t,\, \underline{F}_{t+1} \begin{cases} \xrightarrow{p} \overline{x},\, \underline{D}_{t+1} = \overline{x} - \underline{m},\, \underline{P}_{t+1},\, \underline{C}_{t+1} \\ \xrightarrow{1-p} \underline{x},\, \underline{D}_{t+1} = \underline{x} - \underline{m},\, \underline{P}_{t+1},\, \underline{C}_{t+1} \end{cases}
\end{cases}
$$

The order of events in our model is specified to be as realistic as possible. Alternative designs are also conceivable. For example, the analysts may need some time to issue the next period forecast, so that the immediate price response of the investors in period t does not include the expectations of the analysts. Alternatively, the analysts may issue several forecasts in the period t so that each time the investors need to adjust their expectations and the price of firm's shares. These alternative decision designs do not affect our results given that all firm's outsiders share the same expectations regarding the next period reporting earnings.

3.3 The Investors

From the manager's perspective, the investors represent a homogenous group that determines the price of the firm's shares using all available information efficiently. In line with the empirical evidence (see for example Kasznik and McNichols, 2002; Skinner and Sloan, 2002; Kinney et. al., 2001), we assume that the price response to deviations from the consensus earnings forecast is asymmetric. Investors reward companies for meeting or beating analysts' earnings expectations but penalize them stronger for falling below this target independently of the firm's absolute performance. In models with asymmetric information, the reason underlying this price response is the apparent information content in earnings surprises regarding the future earnings potential of the firm. In this context, earnings manipulation is a signaling device. In our model, the main driver for a manager deciding on her reporting strategy is not her private information. Instead, we attempt to explain manager's decisions by the preferences of the investors while imposing minimal restriction on the distribution of information among the agents in the economy. In particular, we assume that investors are averse against negative earnings surprises because from their perspective, the consensus forecast represents a reference point against which investors judge earnings announcements and determine ultimately the value of the company.

At least since the contribution of Kahneman and Tversky (1979), the importance of reference points became one of the main issues of research on decision making under uncertainty. One of their core findings is that the disutility from a loss looms greater than the utility from a similar gain. Kahneman and Tversky call this property loss aversion. We use the idea that investors may be loss averse when evaluating the earnings reported by the company to model the price response to earnings reports.

In our setting, the price of the firm's shares is determined by two factors. The first is the present value of the firm's earnings reported at the end of each period. The second factor is a premium (or discount) for meeting (falling short of) investors' expectations. Formally, the market value of the firm's shares in period t respectively $t+1$ can be written as:

$$P_t = D_t + \delta \mathbb{E}_t^I D_{t+1} + v(D_t - F_t) \tag{3.1}$$

and

$$P_{t+1} = D_{t+1} + v(D_{t+1} - F_{t+1}) \tag{3.2}$$

where $\delta = \frac{1}{1+r}$ is the discounting rate and r is the interest rate representing the time value of money. F is the consensus earnings forecast. $\mathbb{E}^I$ represents the investors' expectations, which are assumed to be equivalent to the expectations of the analysts $\mathbb{E}^A$.

The function $v(.)$ is the value function proposed by Kahneman and Tversky (1979) describing individual behavior under uncertainty. We use the idea that investors may be loss averse when evaluating the earnings reported by the company and specify the function v as follows:

$$v(\Delta) = \begin{cases} \Delta & \text{for } \Delta \geq 0 \\ \beta\Delta & \text{for } \Delta < 0 \end{cases} \tag{3.3}$$

In our setting, Δ is the earnings surprise in each period, i.e. $\Delta_t = D_t - F_t$ and $\Delta_{t+1} = D_{t+1} - F_{t+1}$. The parameter $\beta > 1$ represents the investors' loss aversion. The higher the loss aversion, the stronger is the investors' disutility from a negative earnings surprise and the lower would be the price of the company's shares in this period. In our setting the loss aversion parameter $\beta > 1$ reflects the asymmetry in the earnings response function observed in empirical studies, e.g. by Kinney et al. (2001).

3.4 The Managers

The manager of the firm is responsible for the earnings reported at the end of each period. The manager chooses her earnings report in order to maximize the expected utility, which is specified as a function of the price of firm's shares in period t and $t+1$, i.e.

$$u_M(P_t, P_{t+1}, \theta) = (1-\theta)g(P_t) + \theta\delta\mathbb{E}_t^M g(P_{t+1}) \tag{3.4}$$

$\mathbb{E}^M(.)$ represents the manager's expectations, $0 \leq \theta \leq 1$ is a factor determining the relative importance of the market price of firm's shares in period t and $t+1$ from the manager's perspective and $g(.)$ is a function describing the dependence of the manager's payoff on the price of the firm's shares. Note that the manager's objective function includes only direct monetary consequences of earnings manipulation. Although including punishments for earnings manipulation and other external payments may be realistic, their consideration would be arbitrary.

There are a number of reasons why the manager might be interested in the market price of the firm's shares. One reason is the manager's compensation. If it is based on shares, the manager can sell them in period t and (or) in period $t+1$ as a response to some liquidity needs for example. If the manager holds shares, the function $g(.)$ is linear and θ represents the percentage of shares that the manager prefers to carry over from period t to period $t+1$. Alternatively, manager's interests may be linked to the price of the firm's shares if the manager's compensation package contains stock options. In this case the function $g(.)$ is non–linear and $1-\theta$ is the percentage of options that the manager is allowed to exercise in period t respectively the percentage of options that expire in period t.

In the following analysis we assume that θ represent the percentage of shares or stock options that the manager desires to carry over to the next period according to her time preferences. It is also realistic to assume that the manager's time preferences are private knowledge.

Finally, we assume that all earnings are paid as dividends at the end of each period. There are no investments or share repurchases, and the company is all-equity financed.

3.5 The Analysts

Empirical evidence suggests that the career advancement of the analysts is closely linked to the accuracy of their predictions (see for example Hong and Kubik, 2003). Since "true" earnings are observable only by the firm's manager, the performance of the analysts can only be measured against the earnings reported by the manager. Thus, the incentive of the average analyst is to provide a forecast that is as close as possible to the reported rather than to the "true" earnings. In particular, we assume that the earnings forecasts of the average analyst are determined by a quadratic loss function.

$$L^A(F_t,F_{t+1}) = -\mathbb{E}^A_{t-1}(F_t - D_t)^2 - \mathbb{E}^A_t(F_{t+1} - D_{t+1})^2 \tag{3.5}$$

where $\mathbb{E}^A$ represents the expectations of the average analysts.

3.6 The Earnings Game

The analysts are aware that their forecasts may affect the earnings reported by the manager since the consensus forecast is used by investors as a target when evaluating the value of firm's shares based on the earnings reports. On the other hand, the manager knows that analysts' consensus forecast affecting the price of the firm's shares and stock options depends on her reporting. Thus, one can expect that the manager and the analysts behave strategically when deciding what earnings numbers to report respectively to forecast.

To describe the situation in which the manager and the analysts act in a setting of strategic interpendence we define the game $\Gamma = [I = \{M,A\},\{S^M,S^A\},\{U^M,U^A\}]$ where I denotes the players in the game, S^M is the strategy space of the manager, S^A is the strategy space of the average analyst, U^M denotes the manager's payoff function and U^A is the payoff function of the average analyst.

In our setting the players of the game include the manager of the firm and the analysts estimating the earnings of the company announced at the end of each reporting period. The investors determine the market price of the firm's shares but they do not behave strategically. Their expectations can be regarded as equivalent to the expectations of the average analyst.[1]

[1] In addition to providing earnings forecasts analysts are required to issue detailed reports with

In our setting, firm's outsiders are required to make decisions under asymmetric information. Since they are not able to observe which state of "true" earnings has been realized in the previous period, they cannot determine the manipulation included in the earnings reported by the manager. This information is however essential for the next period earnings reports expected by firm's outsiders because they know that any manipulation done in period t is reversed in period $t+1$.

The expected manipulation of firm's outsiders is determined by the level of manipulation and the probability that the manager has manipulated the earnings in this way. We denote the level of manipulation expected by the firm's outsiders as $n = (\overline{n}, \underline{n})$, where $\overline{n}$ ($\underline{n}$) is the manipulation conjecture of the firm's outsiders given that $x_t = \overline{x}$ ($x_t = \underline{x}$). Thus, when estimating the probability that the manager has manipulated the earnings reports by $\overline{n}$ respectively $\underline{n}$, firm's outsiders estimate the probability that nature has drawn $\overline{x}$ respectively $\underline{x}$. The prior probability for $x_t = \overline{x}$ is p. The posterior belief of the firm's outsiders after that $x_t = \overline{x}_t$ after observing D_t is denoted by $\mu(\overline{x}|D_t)$. We assume that the posterior beliefs are formed by Bayes rule, i.e.

$$\mu(\overline{x}|D_t) = \frac{p(D_t|\overline{x})p}{p(D_t|\overline{x})p + p(D_t|\underline{x})(1-p)} \tag{3.6}$$

where $p(D_t|\overline{x})$ is the conditional probability for observing D_t given that $x_t = \overline{x}$ and $p(D_t|\underline{x})$ is the conditional probability for observing D_t given that $x_t = \underline{x}$. For example, if $\overline{D}_t = \underline{D}_t = D_t$ then $\mu(\overline{x}|D_t) = p$ and if $\overline{D}_t \neq \underline{D}_t$ then $\mu(\overline{x}|D_t) = 1$ if $x_t = \overline{x}$ and $\mu(\overline{x}|D_t) = 0$ if $x_t = \underline{x}$.

Overall, the payoff of the analysts is maximal if they can "read" behind the earnings numbers. This is possible if they know the possible manipulation actions of the manager and estimate the probability for these actions correctly. In equilibrium, the analysts' conjecture on the level of manipulation $n = (\overline{n}, \underline{n})$ must be correct. Thus, in equilibrium analysts' forecast errors occur only if the analysts updating their beliefs rationally are unable to distinguish which state of "true" earnings has been realized, i.e. if they cannot distinguish whether the manager has manipulated earnings up or down.

The strategies available to the analysts are given by the consensus forecast in each period $S^A = (F_t, F_{t+1} | F_t \in \mathbb{R}, F_{t+1} = (\overline{F}_{t+1}, \underline{F}_{t+1}))$ where $\overline{F}_{t+1}$ is the analysts' consensus forecast for D_{t+1} given that $D_t = \overline{D}_t = \overline{x} + \overline{n}$ and $\underline{F}_{t+1}$ is the analysts' consensus forecast for D_{t+1} given that $D_t = \underline{D}_t = \underline{x} + \underline{n}$.

Using this notation and considering the information structure of the game, the payoff of the analysts (3.5) is redefined as a function of the expected loss in period t and $t+1$ as follows:

$$U^A(F_t, D_t, F_{t+1}, D_{t+1}) = f\left(L^A(F_t), L^A(F_{t+1})\right) \tag{3.7}$$

their private information regarding the earnings prospects of the firms they cover. As non–strategic players, investors are assumed to trust the information provided by the informed party and adjust the price of the firm's shares accordingly.

where

$$L^A(F_t, D_t) = -p(\overline{D}_t - F_t)^2 - (1-p)(\underline{D}_t - F_t)^2$$

and

$$L^A(F_{t+1}, D_{t+1}) \quad = \quad -p(\overline{D}_{t+1} - F_{t+1})^2 - (1-p)(\underline{D}_{t+1} - F_{t+1})^2$$

with

$$\begin{aligned}
\overline{D}_t &= \overline{x} + \overline{n} \\
\underline{D}_t &= \underline{x} + \underline{n} \\
\overline{D}_{t+1} &= \overline{x} - [\mu(\overline{x}|D_t)\overline{n} + (1-\mu)(\overline{x}|D_t)\underline{n}] \\
\underline{D}_{t+1} &= \underline{x} - [\mu(\overline{x}|D_t)\overline{n} + (1-\mu)(\overline{x}|D_t)\underline{n}]
\end{aligned}$$

$\mu(\overline{x}|D_t)$ is the posterior belief of the analysts that the reported earnings D_t are based on the "true" earnings $\overline{x}$ as defined in equation (3.6).

Analysts aiming to provide accurate forecasts are therefore most concerned with estimating the manipulated part of earnings $\overline{n}$ and $\underline{n}$. In period t, the analysts do not have any other information besides the probability distribution of "true" earnings. The best analysts' forecast in this period is therefore the mean of "true" earnings plus the expected manipulation where the expectations are based on the probability distribution of the "true" earnings. In period $t+1$ the analysts are able to update their beliefs regarding the manipulation done in the previous period. In this period, their best forecast is therefore the mean of "true" earnings minus the expected manipulation based on the posterior beliefs of the analysts formed after observing the earnings reported in the period before. Formally, the analysts' best response is:

$$\begin{aligned}
F_t^* &= p\overline{D}_t + (1-p)\underline{D}_t \\
&= p\overline{x} + (1-p)\underline{x} + p\overline{n} + (1-p)\underline{n} \qquad (3.8)
\end{aligned}$$

and

$$\begin{aligned}
F_{t+1}^* &= p\overline{D}_{t+1} + (1-p)\underline{D}_{t+1} \\
&= p\overline{x} + (1-p)\underline{x} - [\mu(\overline{x}|D_t)\overline{n} + (1-\mu)(\overline{x}|D_t)\underline{n}] \qquad (3.9)
\end{aligned}$$

The investors in our model do not behave strategically. They adopt the expectations of the analysts and determine the price of firm's shares. At the end of period t investors observe the earnings reported by the manager, compare them with the analysts' forecasts and build expectations regarding the future reported earnings, which are assumed to be equivalent to the expectations of the analysts. Thus, in dependence on the "true" earnings realization in period t, the prices of companies' share in period t and $t+1$ are either

$$\overline{P}_t = \overline{D}_t + \delta\overline{F}_{t+1} + v(\overline{D}_t - F_t) \qquad (3.10)$$

and

$$\overline{P}_{t+1} = D_{t+1} + v(D_{t+1} - \overline{F}_{t+1}) \qquad (3.11)$$

or

$$\underline{P}_t = \underline{D}_t + \delta \underline{F}_{t+1} + v(\underline{D}_t - F_t) \tag{3.12}$$

and

$$\underline{P}_{t+1} = D_{t+1} + v(D_{t+1} - \underline{F}_{t+1}) \tag{3.13}$$

The strategy space of the manager is defined over the manipulated part of the reported earnings in each state of "true" earnings that realizes in period t, i.e. $S^M = (\overline{m}, \underline{m}) \in [m_{min}, m_{max}]$. This manipulation determined the level of reported earnings in period t and $t+1$ since the "true" earnings are predefined and constant over time.

The manager's payoff is defined in (3.4). More specifically, manager's payoff is $U^M = (\overline{U}^M(.), \underline{U}^M(.))$ in dependence on the "true" earnings realization in period t, where

$$\overline{U}^M(D_t, F_t, F_{t+1}) = (1-\theta)\overline{P}_t(\overline{D}_t, \overline{F}_{t+1}, F_t) + \theta\delta\mathbb{E}_t^M \overline{P}_{t+1}(D_{t+1}, \overline{F}_{t+1}) \tag{3.14}$$

respectively

$$\underline{U}^M(D_t, F_t, F_{t+1}) = (1-\theta)\underline{P}_t(\underline{D}_t, \underline{F}_{t+1}, F_t) + \theta\delta\mathbb{E}_t^M \underline{P}_{t+1}(D_{t+1}, \underline{F}_{t+1}) \tag{3.15}$$

with price functions $P_t = (\overline{P}_t, \underline{P}_t)$ and $P_{t+1} = (\overline{P}_{t+1}, \underline{P}_{t+1})$ as defined in (3.10), (3.11), (3.12) and (3.13).

Using the players' strategy spaces and payoffs listed above, we define two equilibriums. In the first equilibrium, each player takes the action of the other players as given and chooses the strategy that maximizes the payoff. This is summarized in the following definition.

Definition 1 (Equilibrium)**.** *The strategy profile $(m^*, n^*, F_t^*, F_{t+1}^*, P_t^*, P_{t+1}^*)$ with $m^* = (\overline{m}^*, \underline{m}^*)$, $n^* = (\overline{n}^*, \underline{n}^*)$, $F_{t+1}^* = (\overline{F}_{t+1}^*, \underline{F}_{t+1}^*)$, $P_t^* = (\overline{P}_t^*, \underline{P}_t^*)$ and $P_{t+1}^* = (\overline{P}_{t+1}^*, \underline{P}_{t+1}^*)$ together with the posterior beliefs μ of the analysts about the state of "true" earnings in period t is a Bayesian Nash equilibrium (in pure strategies) if:*

1. *μ is determined by Bayes rule as in (3.6) whenever $D_t = (\overline{x} + \overline{m}, \underline{x} + \underline{m})$,*
2. $\overline{P}_t^* = \overline{D}_t^* + \delta \overline{F}_{t+1}^* + v(\overline{D}_t^* - F_t^*)$
   $\overline{P}_{t+1}^* = D_{t+1}^* + v(D_{t+1}^* - \overline{F}_{t+1}^*)$
   $\underline{P}_t^* = \underline{D}_t^* + \delta \underline{F}_{t+1}^* + v(\underline{D}_t^* - F_t^*)$
   $\underline{P}_{t+1}^* = D_{t+1}^* + v(D_{t+1}^* - \underline{F}_{t+1}^*)$
3. *For all $F_t, F_{t+1} \in S^A$*

   $$U^A(F_t^*, F_{t+1}^*; D_t^*, D_{t+1}^*) \geq U^A(F_t, F_{t+1}; D_t^*, D_{t+1}^*)$$

   where the function $U^A(.)$ is defined as in (3.7)
4. *For all $m \in S^M$*

   $$U^M(D_t^*, D_{t+1}^*; F_t^*, F_{t+1}^*) \geq U^M(D_t, D_{t+1}; F_t^*, F_{t+1}^*)$$

   where the function $U^M(.)$ is defined as in (3.14) and in (3.15) and

5. $\overline{m}^* = \overline{n}^*$ *respectively* $\underline{m}^* = \underline{n}^*$.

In the second equilibrium concept, we consider the possibility that the manager is allowed to talk to the analysts and communicate her view on the next period earnings that she is going to report. Such statements summarized in earnings estimates are known as *earnings guidance*. They are relevant for the manager's incentives to manipulate earnings for several reasons. First, earnings guidance influences the consensus forecast since analysts need to adjust their expectations according to the announced reporting strategy in order to minimize their mean forecasts errors, i.e. $\overline{n} = \overline{m}$ respectively $\underline{n} = \underline{m}$. Second, the manager providing earnings guidance would, in equilibrium, anticipate the analysts' reaction to her announcements and change her reporting (manipulation) strategy accordingly. If the manager guides the analysts, she solve a similar problem as the leader in Stackelberg's leader–follower game. The equilibrium in the setting with guidance is defined as follows.

Definition 2 (Equilibrium with Guidance)**.** *The strategy profile* $(m^*, F_t^*, F_{t+1}^*, P_t^*, P_{t+1}^*)$ *with* $m^* = (\overline{m}^*, \underline{m}^*)$, $F_{t+1}^* = (\overline{F}_{t+1}^*, \underline{F}_{t+1}^*)$, $P_t^* = (\overline{P}_t^*, \underline{P}_t^*)$ *and* $P_{t+1}^* = (\overline{P}_{t+1}^*, \underline{P}_{t+1}^*)$ *together with the posterior beliefs* μ *of the analysts about the state of "true" earnings in period* t *is a Bayesian Nash equilibrium (in pure strategies) if:*

1. μ *is determined by Bayes rule as in (3.6) whenever* $D_t = \{\overline{x} + \overline{m}, \underline{x} + \underline{m}\}$,
2. $\overline{P}_t^* = \overline{D}_t^* + \delta \overline{F}_{t+1}^* + v(\overline{D}_t^* - F_t^*)$
   $\overline{P}_{t+1}^* = D_{t+1}^* + v(D_{t+1}^* - \overline{F}_{t+1}^*)$
   $\underline{P}_t^* = \underline{D}_t^* + \delta \underline{F}_{t+1}^* + v(\underline{D}_t^* - F_t^*)$
   $\underline{P}_{t+1}^* = D_{t+1}^* + v(D_{t+1}^* - \underline{F}_{t+1}^*)$
3. *For all* $m \in S^M$

$$U^M(D_t^*, D_{t+1}^*; \mathbb{E}^A(D_t^*), \mathbb{E}^A(D_{t+1}^*)) \geq U^M(D_t, D_{t+1}; \mathbb{E}^A(D_t^*), \mathbb{E}^A(D_{t+1}^*))$$

   where the function $U^M(.)$ *is defined as in (3.14) and in (3.15) and*
   $\mathbb{E}^A(D_t^*) = p\overline{x} + (1-p)\underline{x} + p\overline{m}^* + (1-p)\underline{m}^*$
   $\mathbb{E}^A(D_{t+1}^*) = p\overline{x} + (1-p)\underline{x} - [\mu(\overline{x}|D_t^*)\overline{m}^* + (1-\mu)(\overline{x}|D_t^*)\underline{m}^*]$

3.7 Players' Strategies in Equilibrium

The following analysis aims to show how the manipulation decision of the manager depends on the market conditions, the manager's compensation package and the guidance provided by the manager to the firm's outsiders. The market conditions are defined with respect to the investors' attitude towards earnings reports that are above or below the analysts' consensus forecast. The compensation package of the manager may include either shares or stock options of the company. The manager may or may not provide guidance to the analysts.

When analyzing the relevance of the market conditions, we distinguish two cases. First, we consider a situation where the investors do not use the analysts' forecasts as a reference point when determining the price of firm's shares. We denote this situation by $\overline{B}$ for "non–behavioral". In this case, analysts' forecasts are not a target that the manager aim to meet when deciding to manipulate earnings since there is no premium the manager can get by reporting earnings at or above the consensus forecast. Nevertheless, analysts' expectations with respect to the manipulated part of earnings affect the price of the company shares since the investors are supposed to adapt them fully and adjust the price of the firm's shares accordingly. In this case, the analysts are only information providers. Second, we consider a situation where analysts are target setters and information providers at the same time. We denote this situation by B for "behavioral". In this case, the analysts' reports and forecasts are used by investors not only to build expectations regarding the manipulated part of earnings but also to determine whether the price of the firm's shares should include a premium (or a discount) from meeting (falling short of) the consensus forecast.

The manipulation decision of the manager depends additionally on the manager's compensation package. We assume that the manager is compensated either with company shares (S) or with stock options (C), which can be sold respectively exercised in both periods. The percentage of shares respectively stock options hold by the manager reflects her time preferences, which are assumed to be private knowledge. If the manager holds stocks then her payoff is linked directly to the market price of firm's shares. In contrast, if the manager holds stock options with an exercise price equal to the expected value of "true" earnings, the payoff of the manager is affected only if the price of the firm's shares increases above the fundamental value of the firm, i.e. the expected value of "true" earnings.

The optimal reporting depends additionally on whether the manager does (G) or does not guide ($\overline{G}$). The difference is in the manager's and analysts' attitude toward the actions of the other players. In particular, if the manager provides guidance, the analysts would follow it in order to minimize their mean squared forecast errors. The manager anticipates the reaction of the analysts' and adjust her manipulation strategy accordingly. If the manager does not provide any guidance, she cannot be sure how the analysts will respond to her reporting and choose the manipulation strategy that is best response to some forecast of the analysts.

In equilibrium, the manager's reporting can be either revealing (R) or non–revealing ($\overline{R}$). The reporting is revealing if the firm's outsiders are able to "read" behind the numbers and adjust their expectations in response to the manipulation decision of the manager. The reporting is non–revealing if the firm's outsiders cannot update their beliefs even if they act as rational Bayesians. In the non–revealing equilibrium, the firm's outsiders can be systematically fooled.

3.7.1 Optimal Reporting of a Manager Playing with Behavioral and Non–Behavioral Investors

Consider first the case where the manager holds shares (S), do not guide ($\overline{G}$), and the investors do not consider the analysts' forecasts as a reference point when evaluating the earnings reported by the manager, i.e. the function $v(.)$ does not affect the manager's payoff, or ($\overline{B}$). In this case, the manager does not have incentives to meet the analysts forecasts so that her manipulation decision is driven only by her time preferences θ and the time value of money δ. The following theorem proves this.

Theorem 1 ($S\overline{B}\overline{G}R$ reporting)**.** *If* $\theta \in [0; \frac{1}{1+\delta})$, *we obtain the following revealing*

equilibrium:
$\overline{m}^* = \underline{m}^* = \overline{n}^* = \underline{n}^* = m_{max}$,
$F_t^* = p\overline{x} + (1-p)\underline{x} + m_{max}$
$\overline{F}_{t+1}^* = \underline{F}_{t+1}^* = p\overline{x} + (1-p)\underline{x} - m_{max}$,
$\overline{P}_t^* = \overline{x} + m_{max} + \delta(p\overline{x} + (1-p)\underline{x} - m_{max})$,
$\underline{P}_t^* = \underline{x} + m_{max} + \delta(p\overline{x} + (1-p)\underline{x} - m_{max})$,
$\overline{P}_{t+1}^* = \overline{x} - m_{max}$,
$\underline{P}_{t+1}^* = \underline{x} - m_{max}$
and the posterior beliefs of the analysts $\mu \in [0,1]$ *is a revealing Bayesian Nash equilibrium (in pure strategies).*

If $\theta = \frac{1}{1+\delta}$, *we obtain the following revealing equilibrium:*
$\overline{m}^* = \underline{m}^* = \overline{n}^* = \underline{n}^* = 0$,
$F_t^* = \overline{F}_{t+1}^* = \underline{F}_{t+1}^* = p\overline{x} + (1-p)\underline{x}$,
$\overline{P}_t^* = \overline{x} + \delta(p\overline{x} + (1-p)\underline{x})$,
$\underline{P}_t^* = \underline{x} + \delta(p\overline{x} + (1-p)\underline{x})$,
$\overline{P}_{t+1}^* = \overline{x}$,
$\underline{P}_{t+1}^* = \underline{x}$
and the posterior beliefs of the analysts $\mu \in [0,1]$ *is a revealing Bayesian Nash equilibrium (in pure strategies).*

If $\theta \in (\frac{1}{1+\delta}, 1]$, *we obtain the following revealing equilibrium*
$\overline{m}^* = \underline{m}^* = \overline{n}^* = \underline{n}^* = m_{min}$,
$F_t^* = p\overline{x} + (1-p)\underline{x} + m_{min}$
$\overline{F}_{t+1}^* = \underline{F}_{t+1}^* = p\overline{x} + (1-p)\underline{x} - m_{min}$,
$\overline{P}_t^* = \overline{x} + m_{min} + \delta(p\overline{x} + (1-p)\underline{x} - m_{min})$,
$\underline{P}_t^* = \underline{x} + m_{min} + \delta(p\overline{x} + (1-p)\underline{x} - m_{min})$,
$\overline{P}_{t+1}^* = \overline{x} - m_{min}$,
$\underline{P}_{t+1}^* = \underline{x} - m_{min}$
and the posterior beliefs of the analysts $\mu \in [0,1]$ *is a revealing Bayesian equilibrium (in pure strategies).*

The intuition is the following. If investors do not consider the analysts' forecasts as a reference point, the price of firm's shares depends only on the present value of the reported earnings, i.e. there is no premium (discount) for meeting (falling short of) the analysts' expectations. Thus, the manipulation decision of the manager can be considered as a pure income shift over time depending on the time preferences of the manager θ and the time value of money δ but not on the investors' preferences β with respect to earnings reports above or below the consensus forecast. The more shares the manager aims to sell in the current (following) period, the stronger is her incentive to manipulate earnings up (down) since the manipulation increases the price of the shares that the manager is willing to sell in that period. In equilibrium, the manager prefers to manipulate earnings in order to shift income according to her time preferences although the analysts see this, adjust their expectations and influence the present value of the firm's earnings. The only case where the manager does not have any incentives to manipulate earnings is when money does not have any time value. This is the case where $\delta = 1$ and the manager is indifferent between holding shares in period t or in period $t+1$, i.e. $\theta = \frac{1}{2}$.

To see how the manager's incentives to manipulate earnings change with the market conditions, in the following we consider a situation where the investors require a discount for holding the shares of firms reporting earnings below the analysts' expectations, i.e. if $v(.) \neq 0$ respectively if $\beta > 1$. In this case, the manager has strong incentives to manipulate the earnings even if she is indifferent between holding shares over both periods. In fact, it is this indifference that motivates the manager to manipulate earnings as proved in the following theorem.

Theorem 2 ($SB\overline{GR}$ reporting)**.** *If* $\frac{2}{2+\delta(1+p)+\delta\beta(1-p)} < \theta < \frac{1}{1+\delta}$ *and* $p > \frac{1}{2}$ *we obtain the following non-revealing equilibrium:*
$\overline{m}^* = (1-p)(\underline{x}-\overline{x})$,
$\underline{m}^* = p(\overline{x}-\underline{x})$,
$F_t^* = \overline{F}_{t+1}^* = \underline{F}_{t+1}^* = p\overline{x}+(1-p)\underline{x}$,
$\overline{P}_t^* = \overline{x}+(1-p)(\underline{x}-\overline{x})+\delta(p\overline{x}+(1-p)\underline{x})+v(\overline{x}+(1-p)(\underline{x}-\overline{x})-p\overline{x}-(1-p)\underline{x})$,
$\underline{P}_t^* = \underline{x}+p(\overline{x}-\underline{x})+\delta(p\overline{x}+(1-p)\underline{x})+v(\underline{x}+p(\overline{x}-\underline{x})-p\overline{x}-(1-p)\underline{x})$,
$\overline{P}_{t+1}^* = \overline{x}-(1-p)(\underline{x}-\overline{x})+v(\overline{x}-(1-p)(\underline{x}-\overline{x})-p\overline{x}-(1-p)\underline{x})$,
$\overline{P}_{t+1}^* = \underline{x}-(1-p)(\underline{x}-\overline{x})+v(\underline{x}-(1-p)(\underline{x}-\overline{x})-p\overline{x}-(1-p)\underline{x})$
$\underline{P}_{t+1}^* = \overline{x}-p(\underline{x}-\overline{x})+v(\overline{x}-p(\underline{x}-\overline{x})-p\overline{x}-(1-p)\underline{x})$,
$\underline{P}_{t+1}^* = \underline{x}-p(\underline{x}-\overline{x})+v(\underline{x}-p(\underline{x}-\overline{x})-p\overline{x}-(1-p)\underline{x})$
and the posterior beliefs of the analysts $\mu = p$ *is a non–revealing Bayesian equilibrium (in pure strategies).*

The intuition for the existence of this equilibrium is the following. Given that the "true" earnings are above the consensus forecast, which is equal to the expected "true" earnings in this equilibrium, the manager deciding not to manipulate earnings reports a positive surprise in the current period and a positive or a negative surprise in the period ahead. If, however, the manager sells shares in both periods, she has incentives to "save" the earnings in the current period reporting what the analysts expect and use the "savings" to cover losses that might occur in the next period, when the "true" earnings are below the consensus forecast. This is a better strategy for the manager since reporting earnings below the consensus forecast is associated with a price decline that cannot be compensated with a price increase following a positive earnings surprise in the current period given that $\beta > 1$.

Similarly, if the "true" earnings in the current period are below the consensus forecast, the manager selling shares in both periods is better off if she "borrow" earnings from the next period than to report a loss by reporting truthfully for example. This is because the price decline due to the negative surprise in the current period is stronger than the price increase in the future when the "true" earnings are above the consensus forecast given that $\beta > 1$. Thus, because of the asymmetric price reaction to earnings surprises reflected in the loss aversion parameter $\beta > 1$, the expected payoff of the manager is higher if she "borrows" earnings from the future to prevent reporting negative earnings surprises in the current period and "saves" earnings in the current period in order to prevent reporting negative surprises in the future.

Note that this equilibrium exists only if $\beta > 1$. In other words, only if there is a premium (discount) for meeting (falling short of) the analysts' expectations, the manager has incentives to manipulate earnings in order to meet the analysts' forecasts so that in equilibrium her manipulation cannot be detected by the firm's outsiders. If $\beta = 1$, there is no manager who prefers to play this equilibrium.

Overall, the higher the investors' loss aversion, the higher is the manager's incentives to choose this equilibrium. This is reflected in the restrictions for the manager's time preferences θ. The higher the parameter β reflecting investors' loss aversion, the lower is the lower bound of the parameter θ defining which managers would choose to play this equilibrium. Outside the defined range the managers prefer to follow a different strategy.

In the following we consider the extreme cases, where the manager can either "save" earnings for the future and take the "big bath", i.e. $\overline{m} = \underline{m} = m_{min}$, or "borrow" earnings from the future, i.e. $\overline{m} = \underline{m} = m_{max}$. If the manager decides to follow one of these strategies, her reporting would be revealing since $\overline{D}_t \neq \underline{D}_t$ in the sense that the analysts would be able to detect the manipulation and adjust their beliefs accordingly.

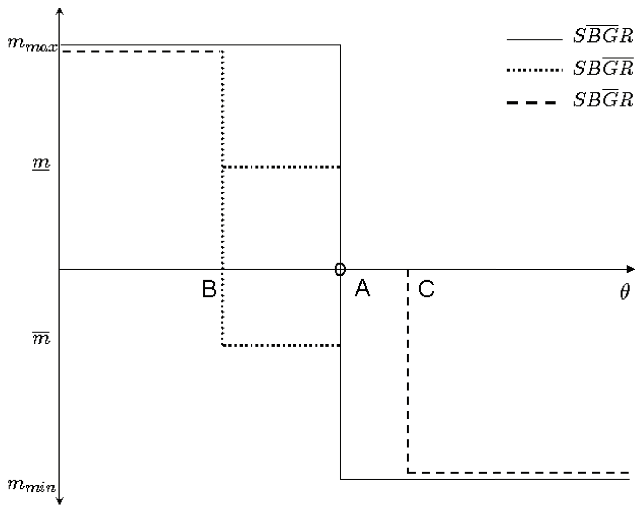
Theorem 3 ($SB\overline{G}R$ reporting)**.** *If condition (B.21) does not hold, we obtain the following revealing equilibria:*
For $\theta \in [0, \frac{2}{2+\delta(1+p)+\delta\beta(1-p)})$
$\overline{m}^* = \underline{m}^* = m_{max}$,
$F_t^* = p\overline{x} + (1-p)\underline{x} + m_{max}$,
$\overline{F}_{t+1}^* = \underline{F}_{t+1}^* = p\overline{x} + (1-p)\underline{x} - m_{max}$,
$\overline{P}_t^* = \overline{x} + m_{max} + \delta(p\overline{x} + (1-p)\underline{x} - m_{max}) + v(\overline{x} - p\overline{x} - (1-p)\underline{x})$,
$\underline{P}_t^* = \underline{x} + m_{max} + \delta(p\overline{x} + (1-p)\underline{x} - m_{max}) + v(\underline{x} - p\overline{x} - (1-p)\underline{x})$,
$\overline{P}_{t+1}^* = \overline{x} - m_{max} + v(\overline{x} - p\overline{x} + (1-p)\underline{x})$,
$\underline{P}_{t+1}^* = \underline{x} - m_{max} + v(\underline{x} - p\overline{x} + (1-p)\underline{x})$
and the posterior beliefs of the analysts $\mu \in [0,1]$ *is a revealing Bayesian equilibrium (in pure strategies).*
For $\theta \in (\frac{(1+\beta)}{(1+\beta)(1+\delta)+\delta p(1-\beta)}, 1]$
$\overline{m}^* = \underline{m}^* = m_{min}$,
$F_t^* = p\overline{x} + (1-p)\underline{x} + m_{min}$,
$\overline{F}_{t+1}^* = \underline{F}_{t+1}^* = p\overline{x} + (1-p)\underline{x} - m_{min}$,
$\overline{P}_t^* = \overline{x} + m_{min} + \delta(p\overline{x} + (1-p)\underline{x} - m_{min}) + v(\overline{x} - p\overline{x} - (1-p)\underline{x})$,
$\underline{P}_t^* = \underline{x} + m_{min} + \delta(p\overline{x} + (1-p)\underline{x} - m_{min}) + v(\underline{x} - p\overline{x} - (1-p)\underline{x})$,
$\overline{P}_{t+1}^* = \overline{x} - m_{min} + v(\overline{x} - p\overline{x} + (1-p)\underline{x})$,
$\underline{P}_{t+1}^* = \underline{x} - m_{min} + v(\underline{x} - p\overline{x} + (1-p)\underline{x})$
and the posterior beliefs of the analysts $\mu \in [0,1]$ *is a revealing Bayesian equilibrium (in pure strategies).*

The results in the last two theorems show that the optimal reporting strategy of the manager depends strongly on her time preferences θ as a function of the time value of money δ, the distribution of true earnings p and the loss aversion of the investors β. If the manager is interested in selling shares in the current and in the following period, she has incentives to meet the analysts' forecasts in the current period as proved in the non–revealing equilibrium in Theorem 2. However, if the manager desires to sell more shares in the current period for example, she would "borrow" earnings from the future independently on the state of "true" earnings. In equilibrium, the analysts would adjust their consensus forecasts up by the amount of the revenues the manager is able to shift over time, i.e. m_{max}. This action of the analysts eliminates the price impact of the manipulation but the manager would still do it. This is because any other strategy is associated with a lower payoff for the manager given the forecasts of the analysts and the time preferences of the manager to sell more shares in the current period, so that in equilibrium the manager manipulates the earnings up as expected by the analysts.

The same intuition applies in the case where the manager is more interested in selling shares in period $t+1$. In this case, the manager would "save" earnings in the current period, i.e. take the "big bath" in order to increase the price of the firm in the period when she plan to sell her shares. Again, in equilibrium the analysts expect this and adjust their forecasts so that the manager does not get any premium for manipulating the earnings. Nevertheless, the manager would not deviate from this strategy since any other strategy is associated with a lower payoff given her time preferences and the forecasts of the analysts.

To derive more general conclusions on the importance of the market conditions for the manager's incentives to manipulate earnings, assume that there are many managers with equally distributed time preferences θ. Then, we can conclude based on the previous analysis that the absolute level of manipulation in the economy is lower if the investors consider the analysts' forecasts as a reference point. This results follows from the fact that in equilibrium where $\beta > 1$ there are some managers playing the non–revealing equilibrium ($SB\overline{GR}$), where the absolute level of manipulation is per definition lower compared to the upper and lower bounds of manipulation, chosen by the managers in the revealing equilibrium where there is no premium (discount) for meeting (falling short of) the investors' expectations ($S\overline{BG}R$). This is illustrated graphically in Figure 3.1.

Figure 3.1: Optimal Manipulation Strategies of Managers Holding Shares and Playing with Behavioral and Non–Behavioral Investors



The figure summarizes the optimal manipulation strategies of a manager holding shares (S), providing no guidance ($\overline{G}$) under different market conditions (B and $\overline{B}$) in dependence on her time preferences θ. The points $A = \frac{1}{1+\delta}$, $B = \frac{2}{2+\delta(1+p)+\delta\beta(1-p)}$, and $C = \frac{1+\beta}{(1+\beta)(1+\delta)+\delta p(1-\beta)}$ represent bounds for the time preferences θ for which the manipulation strategies are part of a revealing (R) or non–revealing ($\overline{R}$) equilibrium proved in Theorem 1, 2 and 3.

3.7.2 Optimal Reporting of a Manager Holding Stock Options

If the manager's compensation package includes stock options instead of shares her optimal reporting strategy changes since the manager's payoff becomes a non–linear function of the price of firm's shares. To analyze the manager's incentive to manipulate earnings, we define θ is the percentage of stock options that the manager desires to carry over to period $t+1$. Hence, $1-\theta$ is the percentage of options that the manager is allowed to exercise in period t.

Let C_t be the market value of a stock option with a strike equal to the mean "true" earnings, $p\overline{x}+(1-p)\underline{x}$, which is denoted by X. In particular,

$$\begin{aligned} \overline{C}_t &= \max(\overline{P}_t - X, 0) & \underline{C}_t &= \max(\underline{P}_t - X, 0) \\ \overline{C}_{t+1} &= \max(\overline{P}_{t+1} - X, 0) & \underline{C}_{t+1} &= \max(\underline{P}_{t+1} - X, 0) \end{aligned} \tag{3.16}$$

where $\overline{P}_t$ and $\underline{P}_t$ are determined by (3.10) respectively (3.12) and $\overline{P}_{t+1}$ and $\underline{P}_{t+1}$ are determined by (3.11) respectively (3.13).

Again, in dependence on whether the analysts are in their role as target setters or not, we distinguish two (revealing) equilibria. The first one summarizes the players' strategies in equilibrium when the analysts are only information providers i.e. if investors do not pay a premium (or require a discount) for meeting (falling short of) the consensus forecast, i.e. $v(.)=0$. The second one summarizes the players' strategies in equilibrium when the analysts are also target setters, i.e. $v(.)\neq 0$.

Theorem 4 ($C\overline{BGR}$ reporting)**.** *If the manager holds stock options and* $v(.)=0$ *we obtain the following equilibrium*
For $\theta \in (\frac{2}{2+\delta};1]$
$\overline{m}^* = \underline{m}^* = m_{min}$
$F_t^* = p\overline{x}+(1-p)\underline{x}+m_{min}$
$\overline{F}^*_{t+1} = \underline{F}^*_{t+1} = p\overline{x}+(1-p)\underline{x}-m_{min}$
$\overline{C}^*_t = \underline{C}^*_t = 0$
$\overline{C}^*_{t+1} = \overline{x}-m_{min}-X$
$\underline{C}^*_{t+1} = \underline{x}-m_{min}-X$
and the posterior beliefs of the analysts $\mu\in[0,1]$ *is a revealing Bayesian equilibrium (in pure strategies).*
For $\theta\in[0,\frac{2(1-p)+\delta(2p-3)}{2(1-p)+\delta(2p-1)})$ *and* $\delta<\frac{2(1-p)}{3-2p}$
$\overline{m}^* = \underline{m}^* = m_{max}$
$F_t^* = p\overline{x}+(1-p)\underline{x}+m_{max}$
$\overline{F}^*_{t+1} = \underline{F}^*_{t+1} = p\overline{x}+(1-p)\underline{x}-m_{max}$
$\overline{C}^*_t = \overline{x}+m_{max}+\delta(p\overline{x}+(1-p)\underline{x}-m_{max})-X$
$\underline{C}^*_t = \underline{x}+m_{max}+\delta(p\overline{x}+(1-p)\underline{x}-m_{max})-X$
$\overline{C}^*_{t+1} = 0$
$\underline{C}^*_{t+1} = 0$
and the posterior beliefs of the analysts $\mu\in[0,1]$ *is a revealing Bayesian equilibrium (in pure strategies).*

To get an intuition on this result particularly in the context of the previous, recall that the manager's best strategy is to report truthfully if she holds shares, the time value of money is equal to zero and the manager is indifferent between selling shares in period t or in period $t+1$ (see Theorem 1). Such indifference cannot make the no–manipulation strategy attractive for the manager holding stock options because her options become worthless if the next period ”true” earnings are low and there is no earnings manipulation pushing the price up. Hence, if the manager is compensated with stock options, she will never prefer to report truthfully in equilibrium.

Comparing the optimal manipulation strategies of the manager in dependence on her compensation package, we can also conclude that there will be less manipulation in absolute terms in the economy if the managers in the economy are compensated with options instead of shares. The reason for this is that options may become worthless whereas the stock price may fall below the fundamentals but it cannot become negative. Thus, the revealing manipulation strategies $\overline{m} = \underline{m} = m_{min}$ and $\overline{m} = \underline{m} = m_{max}$ are attractive only for the manager with time preferences θ that are shifted toward the period where the payoff is positive. More precisely, if the manager's payoff is positive in period $t+1$ but equal to zero in period t, the manager would prefer to sell in period $t+1$. Such preferences are reflected in a higher restriction on the parameter θ for a given manipulation strategy to be optimal. For example, if we compare the restriction on θ for the equilibrium strategy $\overline{m} = \underline{m} = m_{min}$, we can see that the manager holding shares follows this strategy if her time preference parameter θ is lower than the time preference parameter θ of the manager holding stock options, i.e. $\frac{1}{1+\delta} < \frac{2}{2+\delta}$ (see Theorem 1 and 4). This means that the latter follows the manipulation strategy m_{min} if she prefers to exercise her options in period $t+1$ instead of period t which is consistent with the observation that with the strategy m_{min}, $\overline{C}_t = \underline{C}_t = 0$ but $\overline{P}_t > 0$ and $\underline{P}_t > 0$. In other words, because the manager holding stock options carries the risk to get nothing for her stock options in the current period, she would follow the strategy $\overline{m} = \underline{m} = m_{min}$ only if her time preferences are such that she can exercise more options in $t+1$ with $\overline{C}_{t+1} > 0$ and $\underline{C}_{t+1} > 0$ than in t with $\overline{C}_t = \underline{C}_t = 0$ compared to the manager holding shares where $P_t > 0$ and $P_{t+1} > 0$.

Similar considerations apply when we compare the manager's incentives to manipulate earnings in dependence on her compensation package for the case where the manager chooses to play $\overline{m} = \underline{m} = m_{max}$. Since with this strategy $\overline{C}_{t+1} = \underline{C}_{t+1} = 0$ but $\overline{P}_{t+1} > 0$ and $\underline{P}_{t+1} > 0$, the manager holding stock options would follow the strategy only if she has stronger incentives to exercise them in the current period compared to the manager holding stocks. In particular, the strategy is optimal for a manager holding options if she has a lower θ than a manager holding shares, i.e. $\frac{2(1-p)+\delta(2p-3)}{2(1-p)+\delta(2p-1)} < \frac{1}{1+\delta}$ (see Theorem 1 and 4). This is equivalent to the conclusion that the absolute level of manipulation in the economy is lower if the managers in that economy are compensated with options instead of shares.

Having derived conclusions on the implications of the manager's compensation on her manipulation strategies in equilibrium, we continue the analysis by considering the impact of the market conditions in the case that manager is compensated with stock options. In particular, we are interested how the optimal manipulation strategy of the manager holding stock options changes if investors are behavioral, i.e. if they use the analysts' forecasts as a reference point when evaluating earnings reports. In the previous analysis focusing on a manager holding shares we have shown that a manager interested to sell shares in both periods prefers to manipulate the earnings in order to meet the analysts' forecasts. In the following, we analyze the existence of this non–revealing equilibrium for the case that the manager holds stock options.

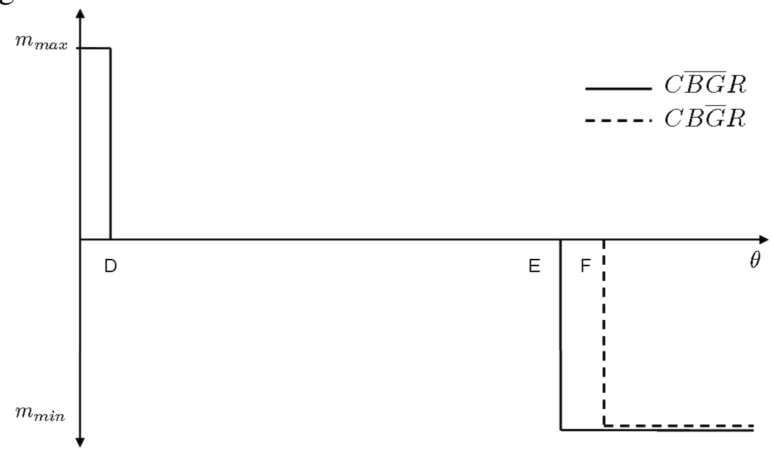
Theorem 5 ($CB\overline{G}R$ reporting)**.** *If the manager holds stock options and* $\theta \in [\frac{4}{4+3\delta p-2\delta p^2}, 1]$ *then*
$\overline{m}^* = \underline{m}^* = m_{min}$,
$F_t = p\overline{x} + (1-p)\underline{x} + m_{min}$,
$\overline{F}^*_{t+1} = \underline{F}^*_{t+1} = p\overline{x} + (1-p)\underline{x} - m_{min}$,
$\overline{C}^*_t = \overline{x} + m_{min} + \delta(p\overline{x} + (1-p)\underline{x} - m_{min}) + \overline{x} - p\overline{x} - (1-p)\underline{x} - X$,
$\underline{C}^*_t = 0$,
$\overline{C}_{t+1} = \overline{x} - m_{min}\overline{x} - p\overline{x} - (1-p)\underline{x} - X$,
$\underline{C}_{t+1} = 0$
and the posterior beliefs of the analysts $\mu \in [0,1]$ *is a revealing Bayesian equilibrium (in pure strategies).*

If investors are behavioral and the manager holds stock options instead of shares then the no–manipulation strategy and the strategy of manipulating earnings in order to meet the analysts' forecasts are dominated strategies from the manager's point of view. Thus, in equilibrium the manager's manipulation strategy is revealing.

To compare the absolute levels of manipulation in the economy with behavioral and non–behavioral investors, we assume that $\delta > \frac{2p-2}{2p-3}$ so that the strategy $\overline{m} = \underline{m} = m_{max}$ is not an equilibrium strategy for the manager holding shares and playing with non–behavioral investors (see Theorem 4).[2] Since the restriction on θ for the strategy $\overline{m} = \underline{m} = m_{min}$ to be optimal for the manager playing with non–behavioral investors, i.e. $\theta > \frac{2}{2+\delta}$ (see Theorem 4), is lower than the restriction on θ for the manager playing with behavioral investors, i.e. $\theta > \frac{4}{4+3\delta p-2\delta p}$ (see Theorem 5) for all $0 < \delta \leq 1$ and $0 \leq p \leq 1$, we may conclude that there will be less manipulation in the economy in absolute terms if the managers in that economy holding stock options play with behavioral than with non–behavioral investors (see Figure 3.2). In other words, the fact that the managers holding stock options play the earnings game with investors considering the analysts' forecasts as a reference point does not increase the absolute level of manipulation in the economy compared to the case with non–behavioral investors.

[2]This is a realistic assumption, since in the extreme case where $p = 0$ the requirement is that $\delta > 2/3$ which correspond to a maximum interest rate of 50%. The higher the probability p the less binding is the restriction on δ.

Figure 3.2: Optimal Manipulation Strategies of a Manager Holding Stock Options and Playing with Behavioral and Non–Behavioral Investors



The figure summarizes the optimal manipulation strategies of a manager holding stock options (C), providing no guidance ($\overline{G}$) under different market conditions (B and $\overline{B}$) in dependence on her time preferences θ. The points $D = \frac{2(1-p)+\delta(2p-3)}{2(1-p)+\delta(2p-1)}$, $E = \frac{2}{2+\delta}$, and $F = \frac{4}{4+3\delta p-2\delta p^2}$ represent bounds for the time preferences θ for which the manipulation strategies are part of the revealing ($\overline{R}$) equilibria proved in Theorem 4 and 5.

3.7.3 Optimal Reporting of a Manager Guiding Analysts

Having analyzed the earnings game with a manager endowed with discretion to manipulate the reported earnings numbers in dependence on the market conditions and her compensation package, in this section we focus on the earnings game with a manager providing earnings guidance to analysts. Studying the manager's incentives to manipulate earnings, we aim to answer the question whether the absolute level of earnings manipulation increase when managers provide guidance compared to the no–guidance case.

To answer this question we consider first an economy with non–behavioral investors and a manager holding shares. If the manager provides earnings guidance, she indirectly announce how she is planning to shift earnings over time. Analysts aiming to minimize the mean squared forecast errors would adjust their estimates according to the provided guidance. The manager considers the best response of the analysts, i.e. how they will respond to the announced guidance, and then she picks a manipulation strategy that is a best response to the predicted response of the analysts. In equilibrium, the analysts adjust their forecasts with the expected manipulation as a response.

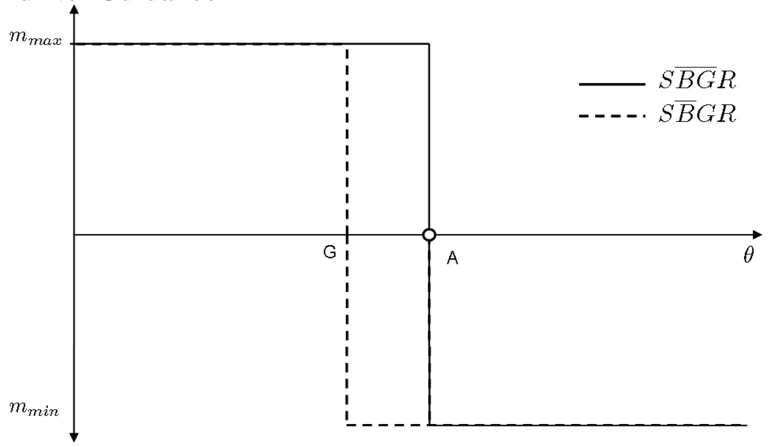
The following theorem formalizes the guidance effect on the manipulation decision of the manager holding shares under the assumption that investors do not use the analysts' forecasts as a reference point, i.e. $v(.) = 0$.

Theorem 6 ($S\overline{B}GR$ reporting)**.** *If the manager guides the analysts and* $v(.) = 0$*, we obtain the following equilibria:*
For $\theta \in [0; 1-\delta]$,

$\overline{m}^* = \underline{m}^* = m_{max}$,
$F_t^* = \overline{F}_{t+1}^* = \underline{F}_{t+1}^* = p\overline{x} + (1-p)\underline{x} - m_{max}$,
$\overline{P}_t^* = \overline{x} + m_{max} + \delta(p\overline{x} + (1-p)\underline{x} - m_{max})$,
$\underline{P}_t^* = \underline{x} + m_{max} + \delta(p\overline{x} + (1-p)\underline{x} - m_{max})$,
$\overline{P}_{t+1}^* = \overline{x} - m_{max}$,
$\underline{P}_{t+1}^* = \underline{x} - m_{max}$
and the posterior beliefs of the analysts $\mu \in [0,1]$ *is a Bayesian Nash equilibrium (in pure strategies).*
For $\theta = \frac{1}{1+\delta}$,
$\overline{m}^* = \underline{m}^* = 0$,
$F_t^* = \overline{F}_{t+1}^* = \underline{F}_{t+1}^* = p\overline{x} + (1-p)\underline{x}$,
$\overline{P}_t^* = \overline{x} + \delta(p\overline{x} + (1-p)\underline{x})$,
$\underline{P}_t^* = \underline{x} + \delta(p\overline{x} + (1-p)\underline{x})$,
$\overline{P}_{t+1}^* = \overline{x}$,
$\underline{P}_{t+1}^* = \underline{x}$
and the posterior beliefs of the analysts $\mu \in [0,1]$ *is a Bayesian Nash equilibrium (in pure strategies).*
For $\theta \in (1-\delta, 1] \setminus \frac{1}{1+\delta}$,
$\overline{m}^* = \underline{m}^* = m_{min}$,
$F_t^* = p\overline{x} + (1-p)\underline{x} + m_{min}$,
$\overline{F}_{t+1}^* = \underline{F}_{t+1}^* = p\overline{x} + (1-p)\underline{x} - m_{min}$,
$\overline{P}_t^* = \overline{x} + m_{min} + \delta(p\overline{x} + (1-p)\underline{x} - m_{min})$,
$\underline{P}_t^* = \underline{x} + m_{min} + \delta(p\overline{x} + (1-p)\underline{x} - m_{min})$,
$\overline{P}_{t+1}^* = \overline{x} - m_{min}$,
$\underline{P}_{t+1}^* = \underline{x} - m_{min}$
and the posterior beliefs of the analysts $\mu \in [0,1]$ *is a Bayesian Nash equilibrium (in pure strategies).*

If the manager guides the analysts she has incentives to ”save” earnings for the future, unless $\theta < 1-\delta$. This is because any earnings manipulation in the current period is almost ”undone” by the analysts, so that the only price impact the manager is able to achieve with the earnings manipulation is in period $t+1$, when the game ends. If $\delta = 1$, i.e. if manipulation is completely ”undone” by the analysts, every manager would follow this strategy independently on her time preferences. In contrast, if the manager does not provide any guidance to the analysts with respect to the earnings she is planing to report, the manager with time preferences $\theta < \frac{1}{1+\delta}$ would choose to ”borrow” earnings from the future, i.e. $\underline{m} = \overline{m} = m_{max}$ as proved in Theorem 1. Both strategies are illustrated in Figure 3.3.

Figure 3.3: Optimal Manipulation Strategies of a Manager Holding Shares with Guidance and No–Guidance



The figure summarizes the optimal manipulation strategies of a manager holding shares (S), providing guidance (G) or not ($\overline{G}$) in dependence on her time preferences θ. The points $G = 1-\delta$ and $A = \frac{1}{1+\delta}$ represent bounds for the time preferences θ for which the manipulation strategies are part of the revealing ($\overline{R}$) equilibria proved in Theorem 1 and 6.

To make the difference in the manipulation policy of the manager more intuitive, assume that the time value of money is equal to zero, i.e. $\delta = 1$. Then, the manager selling more shares in period t, i.e. $\theta < \frac{1}{2}$, would manage earnings up, i.e. $\overline{m} = \underline{m} = m_{max}$ if she does not guide. The same manager would follow a different strategy if she guides the analysts. This manager would anticipate that the analysts' reaction offsets the price effect of the earnings manipulation in the current period and decide to "save" earnings, i.e. $\overline{m} = \underline{m} = m_{min}$ for the future instead. In both cases the manager would report truthfully if she is indifferent between selling shares in the current and the last period, i.e. $\theta = \frac{1}{2}$.

Overall, if the manager holdings shares provides guidance to the analysts, the absolute level of manipulation in the economy does not change. The effect of guidance limits to more "big baths" compared to the case where the manager does not communicate her reporting plans.

In the following, we analyze the effect of guidance on the absolute level of manipulation and the number of "big baths" in the economy if the managers in that economy hold stock options instead of shares.

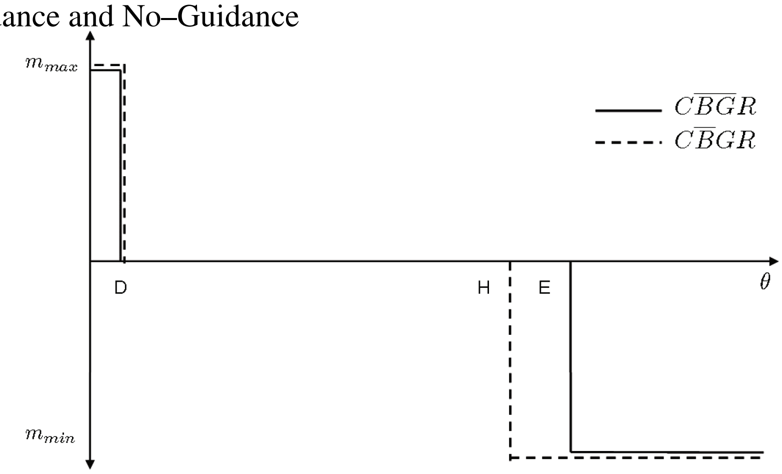
Theorem 7 ($C\overline{B}GR$ reporting)**.** *If the manager holds stock options, $v(.) = 0$, and guides the analysts we obtain the following equilibria.*
For $\theta \in [\frac{(2-p-\delta)(\overline{x}-\underline{x})+\delta X}{(2-p)(\overline{x}-\underline{x})+\delta X}; 1]$
$\overline{m}^* = \underline{m}^* = m_{min}$
$\underline{F}_t^* = p\overline{x} + (1-p)\underline{x} + m_{min}$
$\overline{F}_{t+1}^* = \underline{F}_{t+1}^* = p\overline{x} + (1-p)\underline{x} - m_{min}$
$\overline{C}_t^* = \underline{C}_t^* = 0$
$\overline{C}_{t+1}^* = \overline{x} - m_{min} - X$
$\underline{C}_{t+1}^* = \underline{x} - m_{min} - X$

and the posterior beliefs of the analysts $\mu \in [0,1]$ *is a revealing Bayesian equilibrium (in pure strategies).*
For $\theta \in [0, \frac{2(1-p)+\delta(2p-3)}{2(1-p)+\delta(2p-1)}]$ *and* $\delta < \frac{2p-2}{2p-3}$
$\overline{m}^* = \underline{m}^* = m_{max}$
$F_t^* = p\overline{x} + (1-p)\underline{x} + m_{max}$
$\overline{F}_{t+1}^* = \underline{F}_{t+1}^* = p\overline{x} + (1-p)\underline{x} - m_{max}$
$\overline{C}_t^* = \overline{x} + m_{max} + \delta(p\overline{x} + (1-p)\underline{x} - m_{max}) - X$
$\underline{C}_t^* = \underline{x} + m_{max} + \delta(p\overline{x} + (1-p)\underline{x} - m_{max}) - X$
$\overline{C}_{t+1}^* = \underline{C}_{t+1}^* = 0$
and the posterior beliefs of the analysts $\mu \in [0,1]$ *is a revealing Bayesian equilibrium (in pure strategies).*

Given that the analysts predict that the manager does not manipulate the earnings, it is never optimal for the manager to do so, when she holds stock options instead of shares. Thus, in equilibrium, the analysts would change their beliefs, which again influence the present value of the firm's earnings. The manager anticipates that any manipulation is almost "undone" in period t and would "save" earnings for the the future if she has stronger preferences to exercise options in period $t+1$ compared to the case when she does not provide any guidance.

Therefore, in the case where the managers in the economy hold stock options their decision to guide the analysts has two effects. First, there will be more managers taking the "big bath" compared to the case with no guidance. Second, the absolute level of manipulation in the economy would increase. Both effects are illustrated in Figure 3.4.

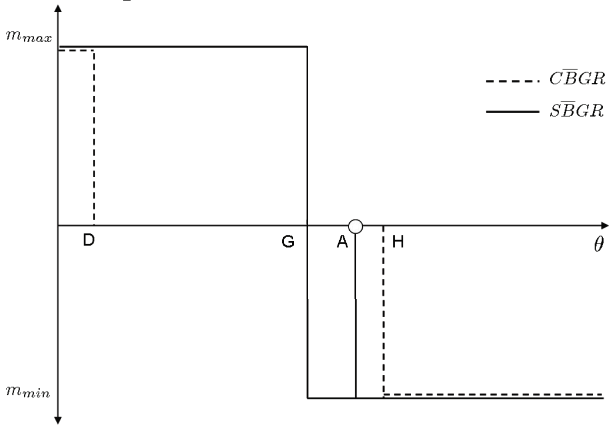
Figure 3.4: Optimal Manipulation Strategies of a Manager Holding Stock Options with Guidance and No–Guidance



The figure summarizes the optimal manipulation strategies of a manager holding stock options (C), providing guidance (G) or not ($\overline{G}$) in dependence on her time preferences θ. The points $E = \frac{2}{2+\delta}$ and $H = \frac{(2-p-\delta)(\overline{x}-\underline{x})+\delta X}{(2-p)(\overline{x}-\underline{x})1\delta X}$ represent bounds for the time preferences θ for which the manipulation strategies are part of the revealing (R) equilibria proved in Theorem 1 and 6.

Having derived conclusions on the effect of guidance on the number of "big baths" and the absolute level of manipulation in the economy, we focus now on the effect of managers' compensation when the managers in that economy guide. We have already seen that the absolute level of manipulation in the economy is lower if the managers providing no guidance are compensated with shares than with stock options. The same conclusion holds also for managers providing guidance. The absolute level of manipulation is lower if the managers are compensated with stock options than with shares, since $\frac{2(1-p)+\delta(2p-3)}{2(1-p)+\delta(2p-1)} < 1-\delta < \frac{(2-p-\delta)(\bar{x}-\underline{x})+\delta X}{(2-p)(\bar{x}-\underline{x})1\delta X}$ (see Theorem 6 and 7). Figure 3.5 illustrates the effect graphically.

Figure 3.5: Optimal Manipulation Strategies of a Manager Providing Guidance and Holding Shares or Stock Options



The figure summarizes the optimal manipulation strategies of a manager holding shares (S) or stock options (C) and providing guidance (G) in dependence on her time preferences θ. The points $A = \frac{1}{1+\delta}$, $D = \frac{2(1-p)+\delta(2p-3)}{2(1-p)+\delta(2p-1)}$, $G = 1-\delta$, and $H = \frac{(2-p-\delta)(\bar{x}-\underline{x})+\delta X}{(2-p)(\bar{x}-\underline{x})1\delta X}$ represent bounds for the time preferences θ for which the manipulation strategies are part of the revealing (R) equilibria proved in Theorem 6 and 7.

3.8 Conclusion

The question whether and why managers manipulate earnings has been one of the main research issues in several empirical and theoretical papers lately. Their main point is that the managers' manipulation decisions are basically motivated by the investors' response to earnings reports. This raises the question whether the managers' incentives to manipulate earnings change if firm's outsiders behave strategically when observing the managers' reporting decisions and determine the price of the firm's shares.

To analyze this problem we consider a three–period economy with one manager, investors and analysts that interact strategically. The main objective of our model is to support to derive conclusions on how the market conditions, the manager's compensation package and the manager's guidance to analysts affect the manager's incentives to manipulate earnings and ultimately the absolute level of manipulation in the whole economy. Based on the analytical results, we can derive the following conclusions.

When evaluating the relevance of the market conditions we distinguish two cases. The first one is the case where investors consider analysts only as providers of information regarding the next period earnings that the manager is reporting. The second one is the case where investors are behavioral, i.e. they consider the analysts' forecasts as a reference point when evaluating the earnings reported by the manager. Our results show that whatever the compensation package of the managers, the fact that the managers play the earnings game with behavioral investors does not increase the absolute level of manipulation in the economy. The reason is that in the case of behavioral investors and managers holding shares, some managers would choose to manipulate the earnings in order to meet the analysts' forecasts. This manipulation is per definition lower than the minimum and maximum bounds of manipulation representing earnings reserves that managers can shift over time. In contrast, if the managers in the economy hold stock options, they would not choose to meet the analysts' forecasts in equilibrium. Instead, they would prefer to shift all there earnings reserves over time. Since this strategy is optimal for less managers when investors are behavioral compared to the case with non–behavioral investors, we can conclude that the loss aversion of the investors does not motivate more managers to shift their earnings reserves over time. In other words, the absolute level of manipulation decreases if managers holding shares instead of stock options play the earnings game with investors who are additionally averse against earnings reports below the consensus forecast.

When assessing the impact of the managers' compensation, we consider a manager holding either shares or stock options. Independent on whether the investors are behavioral or not, the absolute level of manipulation in the economy is lower if the managers in the economy hold stock options than shares. The same conclusion holds also if the managers in the economy provide guidance to analysts and investors are non–behavioral.

The impact of guidance is studied in an economy with managers holding shares and stock options. Independently on their compensation package, there are more managers taking the "big bath" if they guide the analysts compared to the case with no guidance. Since this does not influence the overall level of manipulation in the economy when managers hold stocks, there will be more manipulation if managers hold stock options and guide the analysts compared to the case with no–guidance.

Overall, if regulators aim to reduce the absolute level of manipulation in an economy, they should not try to motivate investors to focus only on the present value of earnings. Instead, they should support the investors' view that earnings reports should be additionally evaluated relative to the consensus forecast, and managers reporting earnings below it, should be punished by a stronger price decline compared to managers beating the consensus by the same amount. When evaluating the advantages and disadvantages of managers' compensation packages, regulators should also support managers compensation plan based on stock options instead of shares. Ultimately, if the managers in the economy are compensated with stock options earnings guidance should be abolished by regulators since this increases the absolute level of manipulation in the economy.

Our model can be extended in several aspects. First, it would be interesting to see how the results change if we consider a strategic game without a final period.

Second, it might be relevant to observe how the managers' incentives to manipulate earnings change if investors behave strategically as well. Finally, introducing other firms competing for the investors' attention may also have interesting implications for the manipulation behavior of the managers in an economy with behavioral investors.

Chapter 4

Managerial Guidance and Analysts' Underreaction

4.1 Introduction

The question whether analysts' expectations are rational has been subject of several empirical studies.[1] The main finding is that analysts' forecasts can be biased and inefficient with respect to variables in the information set of the analysts, including previous forecast errors. If the analysts do not use all available information efficiently when making forecasts, their forecast errors would be serially correlated. Indeed, several studies on the statistical properties of analysts' earnings forecasts by Abarbanell and Bernard (1992), Easterwood and Nutt (1999), Ali et al. (1992), Lys and Sohn (1990) and Mendenhall (1991) find evidence that the forecast errors of analysts are positively autocorrelated.

While from an empirical point of view the evidence on serially correlated forecast errors is undisputable, its theoretical explanation remains controversial. Exploring the question why forecasters make systematic forecast errors some recent studies consider the possibility that analysts underreact to information about future earnings contained in previous earnings and price realizations. For example, Mendenhall (1991), Abarbanell and Bernard (1992), and Ali et al. (1992) find evidence that analysts underreact to earnings news by underestimating the persistence of their earnings forecast errors. Further, Lys and Sohn (1990), Abarbanell (1991), and Ali et al. (1992) document that analysts' forecast errors are related to past changes in the stock prices, which indicates that analysts underreact to information impounded in market prices.

This paper contributes to the literature seeking explanations for the analysts' underreaction by offering a rational economic explanation for their forecasting behavior. We assume that analysts aiming to provide precise forecasts update their expectations based on the managerial guidance regarding the future prospect of the firm. This guidance is provided by managers aiming to reduce the short–term volatility of their firm's shares, mainly driven by the behavior of noise traders. Introducing a random dynamical system compiling the demand of noise and fundamental traders adopting the earnings expectations of the guided analyst, we show that managerial

[1] See Ramnath, Rock and Shane (2006) for a comprehensive overview on the analysts' decision process, the distribution of analysts' forecasts, and the informativeness and efficiency of their output.

guidance may increase the precision of the analysts' forecasts. However, it may also increase the effect estimated empirically as analysts' underreaction. In particular, if the manager provide guidance to analysts, their forecast errors will be positively autocorrelated. The effect is expected to differ among firms with different exposure to noise traders.

To estimate the differences in the guiding policies of the firms in our sample we use the Generalized Maximum Entropy (GME) approach suggested by Golan, Judge and Miller (1996). The results suggest that the managers of growth firms provide stronger guidance than the managers of value firms probably because the impact of noise traders is stronger for growth than for value firms. In the context of our model, this result implies that analysts forecasting the earnings of growth firms have more precise forecasts than analysts following value firms. However, their forecast are expected to be more inefficient due to the stronger guidance of the growth firm managers.

Previous studies aiming at explain the analysts' underreaction search for its origins in psychological biases in individual decision making. For example, Elliot, Phalbrick, and Wiedman (1995) suggest that the observed underreaction of the analysts is due to judgemental biases, which hinders analysts to revise their forecasts sufficiently. Additionally, many experimental studies suggest circumstances where psychological biases such as conservatism and anchoring cause analysts to underreact (e.g. Maines and Hand 1996).

Other studies suggest incentive-based explanations. Based on the assumption that analysts have an asymmetric loss function with respect to their forecasting accuracy Raedy, Shane and Yang (2006) show that analysts maximizing their reputation restrain their forecast revisions so that analysts' forecasts exhibit rationally an underreaction to new information.

This work does not require analysts to be exposed to any behavioral biases nor to have an asymmetric loss function, which is difficult to motivate. In our model, the analysts' underreaction is the result of the optimal guiding policy of managers aiming at minimizing the short-term swings in the price of their firm's shares. If the analysts believe that the manager of the firm they follow has superior knowledge about the future prospect of the firm, they will follow the guidance to increase the precision of their forecast. The manager needs to guide the analysts and influence the demand of fundamental traders in order to dampen the effect of noise traders. Specifically, after price increases (decreases), the manager needs to guide the analysts' expectations down (up) in order to decrease the volatility of the firm's price. Thus, when analysts update their forecasts in the light of increasing (decreasing) prices their forecasts may be systematically lower (higher) than the earnings realizations. However, this inefficiency of the analysts' forecasts is not irrational given that it is the result of the optimal guiding policy of the manager to analysts aiming to increase the precision of their forecasts.

The rest of the chapter is organized as follows. The next section provides background on the determinants and impact of managerial guidance. Section 4.3 describes the model. Section 4.4 analyzes the impact of managerial guidance on the analysts' forecast errors in the context of our model. Section 4.5 describes the estimation procedure used to calibrate the model. The estimation results are presented in section 4.7. Section 4.8 discuss the results in the context of our model and section 4.9 concludes.

4.2 Determinants and Impact of Managerial Guidance

Managers release information that is not required by regulatory standards. This voluntary disclosure includes earnings estimates but also more general information such as qualitative information about market conditions, trend information that may affect the business, industry specific information, quantitative information on business measures and assumptions, or forecasts of factors that may drive future earnings. This information is usually disseminated in conference calls and has a significant impact on the forecast errors of the analysts (see for example Bowen et al., 2002). To the extent that such managers' assessments on the future performance of the firm affect the expectations of firm's outsiders, they represent managerial guidance.

To get an intuition on the managers' incentives to guide firm's outsiders, we consider the evidence of surveys analyzing managers' investors relations policies. For example, Hsieh, Koller and Rajan (2005) show that executives attribute the benefits of providing guidance to a higher valuation, lower volatility and improved liquidity. In a larger survey conducted by the National Investor Relations Institute (NIRI) in Summer 2006, 62% of the surveyed 654 managers respond that they provide guidance in order to decrease the volatility of the firm's stock price.

The volatility of stock prices is driven by investors' demand for firm's shares. If some investors trade on changes in fundamentals but others trade on pure noise, then firm's prices will be excessively volatile (see De Long et al., 1990). This volatility is one of the main concern of firms' managers. Thus, their guiding policy is expected to be closely linked to the activities of noise traders on the stock market.

Price changes and thus stock price volatility is also closely linked to earnings surprises. This relationship is evident in empirical studies on the prominent post-earnings-announcement drift, i.e. the tendency of stock prices to drift in the same direction as the earnings surprise. Thus, managers concerned with the volatility of their stock prices need to focus on minimizing earnings surprises. This can be done either by manipulating the reported earnings and/or by managing the expectations of the analysts regarding the next period earnings. Here, we assume that the manager of the firm focuses on guiding the analysts' forecasts and does not manipulate the reported earnings.

Several empirical studies show that managers are pretty successful in managing the expectations of the analysts. In a recent study Cotter et al. (2006) explore the timing and the extent of analysts' reaction to public managerial guidance and suggest a direct connection between the management information releases and the analysts' revision. Williams (1996) studies analysts' forecast revisions in the month before and in the month after the managers' guidance and finds considerable level of revisions in the analysts' earnings forecasts. Earlier studies by Hassell, Jennings and Lasser (1988) and Baginski and Hassell (1990) provide additional evidence that analysts revise their estimates as a response to management forecasts.

The following section specifies the manager's incentives to guide firm's outsiders in a theoretical framework.

4.3 Model Setup

To analyze the manager's incentives for guidance we model a simple economy with one manager and many investors trading the shares of the firm. In the tradition of Brock and Hommes (1998) we assume that some of the investors judge the prospects of the firm based on its earnings potential (fundamental traders); the rest of the investors make trading decisions based on past changes in the price of firm's shares (noise traders).

The manager can influence his firm's market price only if he manages the expectations of the fundamental traders. We assume that the fundamental traders update their expectations based on the earnings estimates of the analysts following the firm. Thus, to manage the market price of his firm's shares a manager needs to influence the expectations of the analysts regarding the next period earnings.

We specify the manager's problem as a linear quadratic control problem consisting of an objective function, a state equation describing the dynamics of firm's price changes and a feedback rule governing the guidance response of the managers to previous firm's price changes. In particular, we define the manager's objective function as

$$\min_{G_t} W = E\left\{\sum_{t=1}^{\infty} \delta^t b(p_t - p_{t-1})^2\right\} \tag{4.1}$$

where G_t is a control variable describing manager's guidance, p_t is the price of firm's shares in period t, δ_t is a discount factor, and $b > 0$ is an unknown parameter reflecting the manager's preferences with respect to the variance of price changes.

The state equation describes the dynamics of the firm's price changes. In our model the market price of the firm is determined by the demand for firm's shares, which depends on the cumulative demand of the noise and fundamental traders. The demand of the noise traders is driven by their expectations regarding the next period price, which are defined as:

$$\mathbb{E}^N(p_{t+1} - p_t) = a(p_t - p_{t-1}) \tag{4.2}$$

where $a \geq 0$ is an unknown parameter describing the impact of previous price changes on the traders' demand for firm's shares. In the following, we specify the noise traders as positive feedback traders. This is consistent with the empirical evidence that the autocorrelation of returns reverse in dependence on the volatility (see Sentana and Wadhwani, 1992), which indicates the presence of positive feedback traders on the market.

To the extend that the fundamental value of the firm depends on the present value of the firm's earnings, the expectations of the fundamental traders regarding the next period price is determined by changes in their earnings expectations. The latter are assumed to be driven by changes in the consensus forecast of the analysts following the firm, i.e.

$$\mathbb{E}^F(p_{t+1} - p_t) = c\mathbb{E}^G(e_{t+1} - e_t) \tag{4.3}$$

The response of the fundamental traders to changes in the earnings expectations of the analysts $\mathbb{E}^G(.)$ is given by the parameter $c > 0$. If the analysts' consensus forecasts increases (decreases) by a unit, the firm's value estimated by the fundamental traders increases (decreases) as well so that their overall demand for firm's shares increases (decreases) by c units.

We implement the market clearing through Walrasian tattonnement based on the overall demand for firm's shares given by (4.2) and (4.3). Using in addition the assumption that analysts' forecasts are subject to manager's guidance as defined by the function G_t, i.e.

$$\mathbb{E}^G(e_{t+1} - e_t) = G_t \tag{4.4}$$

we get a dynamical system for the evolution of firm's price changes through time

$$p_{t+1} - p_t = a(p_t - p_{t-1}) + cG_t^* + \varepsilon_{1t} \tag{4.5}$$

where $\varepsilon_{1t} \sim N(0, \sigma^2_{\varepsilon_{1t}})$ is a noise term and G_t^* is a feedback or control rule. It describes the optimal guidance response of the manager to price changes. It is specified as

$$G_t^* = g(p_t - p_{t-1}) + \varepsilon_{2t} \tag{4.6}$$

where g is an unknown parameter and $\varepsilon_{2t} \sim N(0, \sigma^2_{\varepsilon_{2t}})$ is a noise term.

The manager's control problem is therefore given by the manager's objective function

$$\min_{g^*} W = E\left\{ \sum_{t=1}^{\infty} \delta^t b(p_t - p_{t-1})^2 \right\} \tag{4.7}$$

the state equation (4.5) and the feedback rule (4.6). Following Chow (1975), we get that the optimal control reaches a steady–state in the sense of having G_t invariant over time if

$$g^* = -\frac{a}{c} \tag{4.8}$$

and

$$b = -h + \delta(\alpha + cg)^2 h \tag{4.9}$$

where h is a Lagrange multiplier. The first condition states that in steady–state, the intensity of the manager's guidance must neutralize the demand of the positive feedback traders by changing the analysts' consensus forecasts, i.e. the demand of the fundamental traders. The second condition states the "pain" that the manager experiences facing the uncertainty in the price changes driven by positive feedback traders while guiding the analysts. Both relations are used together with the state equation (4.5) and the feedback rule (4.6) as consistency conditions to estimate the unknown parameters of the model.

Note that in our economy with managers guiding the expectations of the fundamental investors, firms' market prices are not predictable although there are some positive feedback traders investing systematically. The activities of these noise traders do not have any impact on the market prices, if the managers' guidance is optimal. Given the managers' objective to minimize the variance of stock price changes, their guidance needs to neutralize the impact of the positive feedback traders on the market price of the firm. In this case, firms' price changes will not be correlated over time although there are positive feedback traders on the market.

4.4 The Impact of Managerial Guidance on the Analysts' Forecast Errors

The specification of the manager's guiding policy in the previous section allows us to analyze its impact on the precision and the efficiency of the analysts' earnings forecasts.

By definition, the analysts' forecast error is equal to:

$$z_t = e_t - \mathbb{E}^G(e_t) \tag{4.10}$$

or

$$z_t = \Delta e_t - \mathbb{E}^G(\Delta e_t) \tag{4.11}$$

where $\Delta e_t := e_t - e_{t-1}$.

Then, using equations (4.4) and (4.6), the forecast error of the analysts can also be written as:

$$z_t = \Delta e_t - g(\Delta p_{t-1}) \tag{4.12}$$

where $\Delta p_{t-1} := p_{t-1} - p_{t-2}$. Thus, analysts following the managerial guidance may increase the precision of their forecasts if the market price of the firm at the time of the forecasting falls (increases) but the trend of earnings growth is positive (negative).

Result 1. *If the current market price of the firm goes into the opposite direction as the earnings trend, the analysts following the managerial guidance produce lower forecast errors.*

Although the guidance of the manager may increase the precision of the analysts forecasts, it has a negative impact on their efficiency. In the following we show that analysts' forecasts based on the guidance by managers are positively autocorrelated.

Forecast errors exhibit a positive autocorrelation if:

$$\mathbb{E}_{t-1}(z_t z_{t+1}) = \mathbb{E}_{t-1}(\Delta e_t - g\Delta p_{t-1})(\Delta e_{t+1} - g\Delta p_t) > 0 \tag{4.13}$$

or

$$\begin{aligned}\mathbb{E}_{t-1}(z_t z_{t+1}) \quad = \quad & \mathbb{E}_{t-1}(\Delta e_t \Delta e_{t+1}) - \mathbb{E}_{t-1}(g\Delta e_t \Delta p_t) \\ & - \mathbb{E}_{t-1}(g\Delta p_{t-1}\Delta e_{t+1}) + \mathbb{E}_{t-1}(g^2 \Delta p_{t-1}\Delta p_t) > 0\end{aligned} \tag{4.14}$$

We assume that the firm's earnings follow a (seasonal) random walk with a drift, i.e.

$$e_t = \mu + e_{t-1} + \varepsilon_t \tag{4.15}$$

where $\varepsilon_t \sim N(0, \sigma_\varepsilon)$ is white noise.
The first term of the equation is equivalent to

$$\mathbb{E}_{t-1}(\Delta e_t \Delta e_{t+1}) = \mu^2$$

The second term of the equation is equivalent to

$$\mathbb{E}_{t-1}(g\Delta e_t \Delta p_t) = g\mathbb{E}_{t-1}[\Delta e_t((a + cg)\Delta p_{t-1} + \varepsilon_{t1})] = g[\mu(a + cg)]\Delta p_{t-1} = 0$$

given the optimal guidance policy $g = -\frac{a}{c}$.
The third term of the equation is

$$\mathbb{E}_{t-1}(g\Delta p_{t-1}\Delta e_{t+1}) = g\mu\Delta p_{t-1}$$

The last term is

$$g^2\Delta p_{t-1}\mathbb{E}_{t-1}(\Delta p_t) = 0$$

since under optimal guiding $\mathbb{E}_{t-1}(\Delta p_t) = 0$. Thus, the forecast errors are positively autocorrelated if

$$\mathbb{E}_{t-1}(z_t z_{t+1}) = \mu^2 - \mu g\Delta p_{t-1} > 0 \tag{4.16}$$

This is true for $-\frac{|\mu|}{|g|} < \Delta p_{t-1} < \frac{|\mu|}{|g|}$.

If we focus on stocks with a positive earnings drift, i.e. $\mu > 0$, the analysts' forecast errors will be positively autocorrelated, when firm's prices increase as well. For example, in a boom market when earnings tend to increase and the market price of firm's shares increase as well, managers need to guide analysts' expectations down. As a result, analysts' forecasts will be systematically too low, i.e. the analysts underreact. If the price of the firm decreases although the earnings drift is positive, the managers need to guide the expectations of the analysts up in order to dampen the effect of the positive feedback traders betting on further decreasing prices. This guidance reduces the forecast error of the analysts as discussed above, but given that the impact of the positive feedback traders is limited and there are no large negative shocks in the economy so that the optimal guidance is not that strong, analysts' forecasts will be too low again. Thus, analysts' following the managerial guidance would have positively correlated forecast errors.

Result 2. *There is a positive autocorrelation in the analysts' forecast errors if there is a price change supporting the earnings trend. If this condition does not hold, the forecast errors of the analysts will be positively autocorrelated if the positive feedback traders do not dominate the market so that the manager does not need to guide too strongly.*

Note that if positive feedback traders dominate the market, then the manager needs to guide stronger when prices decline. Consequently, the analysts' forecasts may increase above the mean earnings growth, i.e. the analysts' forecast will be too high. Given the positive forecast error in the previous period, analysts' forecast errors will then exhibit a negative autocorrelation.

In the literature, the relationship between analysts' forecast errors and previous realizations of variables known by the analysts is used as an indicator for inefficient forecasting. Several empirical studies analyzing the properties of analysts forecasts find a significant positive relationship between the analysts' forecast errors and the firm's performance and also between the analysts' forecast errors in two subsequent periods (see Abarbanell and Bernard, 1992; Easterwood and Nutt, 1999; Ali, Klein and Rosenfeld, 1992; Lys and Sohn, 1990 and Mendenhall, 1991). A common explanation for this empirical result is that the analysts underreact to information, i.e. analysts' systematically underestimate the trend in the firm's performance probably because of some behavioral bias. As a consequence, after a positive (negative) firm's performance the forecast error is positive (negative). The same relationship can be observed in our model as well: If the firm's performance has a positive (negative) trend, the forecast error of the analysts will be positive (negative) when the current price change supports the development of the firm's performance or if the current price decreases (increases) but only moderately, for example because of the limited impact of positive feedback traders. Note that our explanation of the observed relationship does not require analysts to be exposed to any behavioral bias. In our model, the relationship is observed because managers provide guidance to firm's outsiders in order to dampen the effect of the positive feedback traders increasing the variance of firm's price changes.

To estimate whether the proposed relationship can be explained by managerial guidance, we study the price dynamics of different firms in order to recover the unknown parameters of the problem along with the parameter of the feedback rule. We expect to see significant differences in the preferences and in the guiding policies of firms with different levels of uncertainty in their earnings and price growth. Such differences can be observed for example by growth and value stocks. To the extent that earnings are uncertain and the firm is difficult to be evaluated on the basis of fundamentals, there will be more investors evaluating the firm on the basis of its past performance. According to our model, the managers of such firms would have stronger incentives to provide guidance since it reduces the impact of the positive feedback traders on the variance of stock price changes. The implications for the analysts' forecasts is then analyzed in the context of our model.

4.5 Estimation Procedure

To estimate the unknown parameters of the model we propose the use of the Generalized Maximum Entropy (GME) estimation method as described by Golan, Judge and Miller (1996). The basic objective of the method is to estimate the unknown parameters with minimal distributional and sampling assumptions. This objective is similar in philosophy to other approaches as for example the Generalized Method of Moments, where the basic objective is first to search for the "natural weight" of each observation and then to use it in order to form an empirical likelihood based on some moments. In contrast, the GME does not use any moments or side–conditions a priori. Instead with the GME one maximizes the traditional entropy functional but subject to noisy moment representations, without imposing any sampling assumptions or zero moment conditions.

The principle of maximum entropy is based on the idea that when estimating the probability distribution of the model parameters from a sample one should select the distribution, which leaves the largest remaining uncertainty (maximum entropy) consistent with some constrains. Under this criterion, there are no additional assumptions or biases introduced in the estimation. Additionally, the estimation can be done without imposing assumptions on the underlying data generation process. Thus, given the linear-quadratic model in (4.7), (4.5) and (4.6), we estimate the unknown parameters without imposing assumptions regarding the exact relationship between sample and population moments. Assuming that the parameters and the noise terms with unknown distributions are both unknown, we aim to recover them simultaneously from the price data of a particular firm.

To achieve this goal we reformulate the unknown parameters and noise terms as discrete random variables with finite supports. Accordingly, we may write the control problem in terms of the random variables. The estimation problem is then to recover the probability distributions for the unknown parameters and noise terms that reconciles the available information with the observed sample information. At the optimum, the probabilities satisfy some consistency constraints, which are given by the state equation (4.5), the feedback rule (4.6) and the steady–state conditions (4.8) and (4.9). Given these probability distributions and the supports used in the estimation we can recover the parameters of the model. A precise description of the estimation procedure is given in the appendix.

4.6 Data and Descriptive Statistics

To recover the unknown parameters of the linear quadratic control problem defined in (4.1), (4.5) and (4.6) for different firms, we use quarterly price data from Datasteam starting in the third quarter of 2000 and ending at the fourth quarter of 2006. We choose the third quarter of 2000 as a starting date since in October 2000 the SEC introduced the Regulation Fair Disclosure (Reg FD) prohibiting the private dialogue between managers and analysts. We expect that after Reg FD, the market reaction to earnings forecasts and announcements changes since the dissemination of information is intensified. Previous research by Heflin et al. (2003) support this view. They observe that after Reg FD the return volatility after earnings announcements, which is part of the manager's objective function, has decreased. This result indicates that the effect of managers' guidance may differ prior and after Reg FD. We take this into account by focusing on the period after Reg FD.

We limit our analysis to firms that usee US GAAP reporting standard and choose 40 firms included in the S&P 500 Index. The selection is done based on two criteria: the firms' market capitalization as of December 2006 and the firms' fundamentals relative to their market value. We focus on the largest firms in the index to keep the group homogenous with respect to size since large firms are usually covered by more analysts than small and mid–cap firms. The market capitalization of the firms in our sample ranges between 34$ billions and 422$ billions.

To distinguish whether a firm is a value or a growth firm, we use the S&P500/Citigroup Growth and Value Indices. The main advantage of these indices is that firms' classification is based not only on the price-to-book ratios of the firms but also on additional variables.[2]

Table 4.1 provides summary statistics on the quarterly price changes of the growth firms included in our sample.

[2]The growth criteria are the five-years historical earnings per share growth rate, sales per share growth rate and the five years average annual internal growth rate. The value criteria are the book value per share to price, the sales per share to price, the cash flow per share to price, and the dividend yield.

Table 4.1: Summary Statistics Growth Stocks

The summary statistics are calculated for changes in quarterly prices. For the time period from Q1 2002 to Q4 2006 there are 26 observations. Mean and median values in italic are statistically different from zero at the 5% confidence level. The Augmented Dickey Fuller (ADF) test statistic is performed for an intercept and a trend with maximum 5 lags. The p–values are reported in parenthesis.

	Mean	Median	StDev	Skew.	Kurt.	JB-stat	ADF-test
AIG	-0.378	-0.035	9.064	0.002	1.929	1.242 (0.538)	-6.199 (0.000)
Am.Express	0.414	1.865	4.488	-0.921	3.527	3.976 (0.137)	-4.636 (0.006)
Amgen	0.812	-0.725	8.654	0.725	3.569	2.628 (0.269)	-6.832 (0.000)
Cisco	-1.604	0.070	6.749	-1.823	6.411	27.02 (0.000)	-4.765 (0.004)
Comcast	-0.067	0.175	4.402	-0.449	2.499	1.145 (0.564)	-4.693 (0.005)
Dell	1.173	1.860	3.290	-0.145	3.126	0.109 (0.947)	-6.017 (0.000)
EBay	0.496	0.013	5.668	-0.168	2.222	0.779 (0.677)	-1.004 (0.922)
Exxon	1.173	1.860	3.290	-0.145	3.126	0.109 (0.947)	-6.017 (0.000)
HomeDepot	-0.862	0.445	6.838	-1.222	4.189	8.008 (0.018)	-6.489 (0.000)
IBM	-0.805	0.715	11.093	-0.349	3.100	0.538 (0.764)	-5.549 (0.001)
J&J	1.026	1.233	5.059	-1.037	4.703	7.801 (0.020)	-6.695 (0.000)
Lowe’s	0.629	0.045	3.162	0.256	2.050	1.262 (0.532)	-4.699 (0.007)
Medtronic	-0.154	0.285	4.270	-0.616	3.216	1.694 (0.429)	-7.072 (0.000)
Oracle	-0.737	0.119	3.536	-1.623	6.110	21.90 (0.000)	-6.757 (0.000)
Pepsico	1.008	1.255	4.199	-0.993	4.865	8.040 (0.018)	-6.861 (0.000)
P&G	1.201	1.123	3.123	-0.045	2.774	0.064 (0.969)	-4.663 (0.007)
Un.Health	*1.542*	*1.983*	3.291	-0.756	5.551	9.530 (0.009)	-4.608 (0.006)
Walgreen	0.532	0.760	3.921	-0.112	2.996	0.054 (0.973)	-5.767 (0.000)
Wal Mart	-0.340	-0.420	5.817	-0.293	2.687	0.479 (0.787)	-9.716 (0.000)
Yahoo	-1.452	-0.407	9.075	-3.373	15.479	217.9 (0.000)	-5.109 (0.002)

The average firms’ price changes range between -1.6 and 1.5 with standard deviations between 3.1 and 11.1. The skewness and kurtosis range between -3.4 and 0.7 respectively between 1.9 and 15.5 indicating that the price changes of some firms are probably not normal distributed. However, the JB-statistic shows that the price changes of most of the firms are not statistically different from the normal distribution. Further, firms’ price changes do not have a unit root according to the ADF-statistic except for one firm. This allows us to use ordinary least squares to estimate the autocorrelation of firms’ price changes. The results reported in Table 4.2 suggest that price changes of most of the growth firms in our sample do not depend on their previous realizations. Including higher lags in the analysis does not change the conclusion that firms’ quarterly price changes are not autocorrelated over time.

Table 4.2: Autocorrelation in Price Changes of Growth Stocks

$p_t - p_{t-1} = c_0 + \sum_{i=0}^{3} c_i(p_{t-i} - p_{t-i-1})$.

The Breusch–Godfrey (BG) statistic is calculated with 3 lags. P–values are reported in parenthesis.

	c_0	c_1	c_2	c_3	BG-test
AIG	-1.781 (0.350)	-0.383 (0.117)	-0.210 (0.349)	-0.007 (0.975)	0.449 (0.772)
Am.Express	0.639 (0.492)	0.072 (0.729)	-0.084 (0.684)	0.255 (0.227)	2.477 (0.099)
Amgen	0.505 (0.762)	-0.105 (0.637)	0.074 (0.737)	-0.366 (0.085)	0.917 (0.455)
Cisco	-0.248 (0.829)	0.170 (0.407)	0.423 (0.021)	-0.345 (0.056)	2.392 (0.107)
Comcast	-0.263 (0.780)	0.083 (0.726)	-0.146 (0.519)	-0.256 (0.252)	0.255 (0.856)
Dell	0.848 (0.279)	0.048 (0.838)	0.293 (0.181)	0.075 (0.733)	0.338 (0.798)
EBay	0.785 (0.561)	-0.234 (0.312)	-0.090 (0.730)	0.248 (0.368)	2.787 (0.074)
Exxon	0.848 (0.279)	0.048 (0.838)	0.293 (0.181)	0.075 (0.733)	0.338 (0.798)
HomeDepot	-0.507 (0.710)	-0.292 (0.216)	-0.041 (0.846)	-0.038 (0.846)	0.280 (0.839)
IBM	-0.922 (0.656)	0.002 (0.993)	-0.233 (0.233)	0.141 (0.481)	0.095 (0.962)
J&J	1.318 (0.244)	-0.260 (0.276)	0.082 (0.741)	-0.270 (0.255)	0.623 (0.610)
Lowe's	1.140 (0.163)	-0.431 (0.077)	0.019 (0.942)	-0.024 (0.915)	3.228 (0.050)
Medtronic	-0.321 (0.732)	-0.446 (0.065)	-0.167 (0.513)	-0.019 (0.939)	1.722 (0.203)
Oracle	-0.219 (0.794)	-0.027 (0.905)	0.375 (0.092)	-0.077 (0.738)	12.22 (0.000)
Pepsico	1.250 (0.183)	-0.433 (0.074)	-0.211 (0.398)	0.004 (0.984)	0.304 (0.822)
P&G	1.903 (0.032)	-0.366 (0.141)	-0.320 (0.187)	0.022 (0.923)	5.368 (0.009)
Un.Health	1.124 (0.376)	-0.001 (0.996)	0.032 (0.893)	0.130 (0.693)	1.146 (0.361)
Walgreen	0.431 (0.574)	-0.269 (0.231)	0.031 (0.882)	-0.354 (0.091)	1.368 (0.288)
Wal Mart	-0.166 (0.855)	-0.758 (0.005)	-0.078 (0.765)	0.099 (0.615)	0.486 (0.697)
Yahoo	0.540 (0.364)	0.189 (0.406)	0.244 (0.006)	-0.061 (0.443)	0.824 (0.500)

Summary statistics for the value firms are provided in Table 4.3.

Table 4.3: Summary Statistics of Value Stocks

The summary statistics are calculated for changes in quarterly prices. For the time period from Q1 2002 to Q4 2006 there are 26 observations. Mean and median values in italic are statistically different from zero at the 5% confidence level. The Augmented Dickey Fuller (ADF) test statistic is performed for an intercept and a trend with maximum 5 lags. The p–values are reported in parenthesis.

	Mean	Median	StDev	Skew.	Kurt.	JB-stat	ADF-test
AT&T	-0.408	-0.57	3.85	0.658	4.458	4.179 (0.124)	-5.216 (0.002)
Bank of America	*1.049*	1.365	2.528	-0.400	3.039	0.694 (0.707)	-6.170 (0.000)
Bristol Myers	-0.935	-0.183	5.528	-0.479	5.034	5.480 (0.065)	-5.207 (0.003)
Citigroup	0.221	0.365	4.494	-0.858	4.742	6.476 (0.039)	-5.422 (0.001)
ConocoPhilips	1.462	*1.175*	3.675	0.095	3.645	0.490 (0.783)	-3.683 (0.043)
Duke Energy	0.105	0.980	4.749	-1.147	6.285	17.39 (0.000)	-5.487 (0.001)
Du Pont	-0.231	-0.363	3.407	-0.272	2.489	0.603 (0.740)	-6.489 (0.000)
Fannie Mae	-0.224	-1.075	7.392	0.571	3.478	1.661 (0.436)	-7.080 (0.000)
Hewlett Packert	-0.590	-0.015	5.198	-0.653	3.025	1.847 (0.397)	-6.318 (0.000)
JPMorgan Chase	-0.184	-0.060	5.296	-0.154	4.087	1.383 (0.501)	-3.948 (0.029)
Merck	-0.867	0.533	6.621	0.105	3.150	0.072 (0.965)	-4.987 (0.003)
Merrill Lynch	1.257	3.390	8.035	-0.063	1.843	1.467 (0.480)	-5.598 (0.001)
Morgan Stanley	-0.093	0.735	8.146	-0.709	3.589	2.551 (0.279)	-4.437 (0.010)
Motorola	-0.385	0.330	3.881	-2.025	8.125	46.22 (0.000)	-8.236 (0.000)
Sprint Nextel	-1.429	-0.472	4.824	-2.162	7.558	42.75 (0.000)	-4.453 (0.008)
Time Warner	-1.583	-0.660	4.776	-0.195	2.719	0.250 (0.882)	-3.752 (0.042)
Tyco	-0.727	0.025	6.785	-1.750	6.867	29.47 (0.000)	-3.865 (0.030)
Verizon	-0.948	-0.050	5.099	-0.967	4.515	6.539 (0.038)	-6.103 (0.000)
Washington Mut.	0.965	1.645	3.852	-0.753	3.253	2.529 (0.282)	-6.629 (0.000)
Wells Fargo	0.571	0.763	1.650	0.011	2.351	0.457 (0.796)	-6.198 (0.000)

The average price changes of the value firms range between -1.6 and 1.5 with standard deviations between 1.6 and 8.1. The skewness and kurtosis range between

-2.2 and 0.7 respectively between 1.8 and 8.1 indicating that the price changes of some firms are probably not normal distributed. However, most of the value firms have price changes that are statistically not different from the normal distribution according to the JB-statistic. Further, according to the ADF-statistic, the price changes of the value firms included in our sample do not have a unit root. This allows us to use ordinary least squares to estimate the autocorrelation of firms' price changes. The results reported in Table 4.4 suggest that as in the case of growth firms the price changes of most of the value firms in our sample do not depend on their previous realizations. Including higher lags in the analysis does not change the conclusion that firms' quarterly price changes are not autocorrelated over time.

Table 4.4: Autocorrelation in Price Changes of Value Stocks

$p_t - p_{t-1} = c_0 + \sum_{i=0}^{3} c_i(p_{t-i} - p_{t-i-1})$.

The Breusch–Godfrey (BG) statistic is calculated with 3 lags. P–values are reported in parenthesis.

	c_0	c_1	c_2	c_3	BG-test
AT&T	0.296 (0.617)	0.437 (0.023)	0.017 (0.906)	0.418 (0.007)	0.758 (0.534)
Bank of America	1.717 (0.033)	-0.331 (0.182)	-0.059 (0.816)	-0.021 (0.924)	2.696 (0.081)
Bristol Myers	-0.956 (0.361)	0.538 (0.025)	-0.410 (0.042)	0.196 (0.300)	0.841 (0.491)
Citigroup	-0.039 (0.970)	-0.094 (0.684)	-0.097 (0.675)	-0.004 (0.987)	0.453 (0.719)
ConocoPhilips	0.752 (0.436)	0.312 (0.196)	0.021 (0.925)	0.109 (0.630)	0.396 (0.758)
Duke Energy	-0.261 (0.776)	-0.022 (0.925)	0.356 (0.074)	-0.140 (0.493)	1.139 (0.363)
Du Pont	-0.010 (0.987)	-0.554 (0.028)	-0.479 (0.047)	-0.245 (0.263)	0.732 (0.548)
Fannie Mae	-1.152 (0.371)	-0.415 (0.083)	0.200 (0.298)	0.196 (0.292)	0.124 (0.944)
Hewlett Packert	0.681 (0.445)	-0.089 (0.688)	0.285 (0.127)	0.223 (0.211)	1.778 (0.192)
JPMorgan Chase	-0.198 (0.836)	0.138 (0.477)	0.153 (0.388)	0.037 (0.836)	1.642 (0.219)
Merck	-1.709 (0.270)	-0.014 (0.955)	-0.054 (0.798)	-0.156 (0.459)	0.416 (0.744)
Merrill Lynch	0.457 (0.798)	-0.03 (0.899)	-0.093 (0.700)	0.126 (0.585)	2.819 (0.072)
Morgan Stanley	0.162 (0.915)	0.166 (0.495)	0.352 (0.097)	-0.177 (0.395)	3.195 (0.052)
Motorola	0.331 (0.561)	-0.066 (0.779)	0.302 (0.041)	0.047 (0.761)	1.48 (0.258)
Sprint Nextel	0.026 (0.962)	-0.149 (0.519)	0.057 (0.750)	0.145 (0.282)	0.589 (0.631)
Time Warner	-0.681 (0.501)	0.177 (0.376)	0.265 (0.165)	0.105 (0.578)	2.474 (0.099)
Tyco	-1.253 (0.417)	0.277 (0.226)	-0.141 (0.545)	0.007 (0.975)	1.265 (0.320)
Verizon	-0.664 (0.553)	-0.111 (0.647)	0.005 (0.982)	-0.018 (0.929)	1.067 (0.391)
Washington Mut.	0.771 (0.368)	-0.450 (0.048)	-0.006 (0.977)	-0.005 (0.981)	1.918 (0.167)
Wells Fargo	0.932 (0.032)	-0.332 (0.118)	-0.255 (0.261)	-0.287 (0.196)	0.201 (0.894)

The missing autocorrelation of price changes of growth and value stocks is consistent with our model since optimal guidance neutralizes the effect of the positive feedback traders on the price dynamics of the firm. If the manager of the firm does not intervene against the activities of positive feedback traders, we would observe a positive autocorrelation of stock price changes. The autocorrelation would be negative if the guidance is too strong relative to the impact of the positive feedback traders on stock prices. Both guiding policies cannot be considered as rational given the manager's control problem.

4.7 Estimation Results

The estimation procedure described in section 4.5 and in the appendix is applied to estimate the unknown parameters of the optimal control problem that the managers of different value and growth firms need to solve when deciding their guiding strategies. The GME approach requires to specify the support of each of the unknowns in order to reflect prior knowledge about the parameters. Since our model does not provide specific restrictions on the upper and lower bounds on the parameter space, we run the estimation for a variety of plausible bounds. For each combination of bounds we estimate the coefficients and calculate the corresponding entropy.

We choose six supports in equidistant fashion for each of the parameters subject to estimation. We first use broad supports and then refine them while evaluating changes in the corresponding entropy. For the parameter a we choose the supports

$$
\begin{aligned}
z^a &= (0.1, 0.3, 0.5, 0.7, 0.9, 1.0)\\
z^a &= (0.05, 0.1, 0.15, 0.2, 0.25, 0.3)\\
z^a &= (0.4, 0.5, 0.6, 0.7, 0.8, 1.0)
\end{aligned}
$$

The parameter g is estimated over the supports

$$
\begin{aligned}
z^g &= (-1, -0.9, -0.7, -0.5, -0.3, -0.1)\\
z^g &= (-0.3, -0.25, -0.2, -0.15, -0.1, -0.05)\\
z^g &= (-1, -0.8, -0.7, -0.6, -0.5, -0.4)
\end{aligned}
$$

For the parameters b and h we use the supports

$$
\begin{aligned}
z^b &= (0.1, 0.3, 0.5, 0.7, 0.9, 1)\\
z^b &= (0.5, 1, 1.5, 2, 2.5, 3)\\
z^h &= (-1, -0.9, -0.7, -0.5, -0.3, -0.1)\\
z^h &= (-3, -2.5, -2, -1.5, -1, -0.5)
\end{aligned}
$$

The supports for both noise terms are chosen symmetrically around zero, i.e.

$$v^e = (-0.5, -0.25, -0.1, 0.1, 0.25, 0.5)$$

The parameter c reflecting the demand response of the fundamental traders to the earnings estimates of the guided analysts is set to be equal to 1. This assumption is not restrictive given that the manager knows how the fundamental traders respond to the provided guidance. In this case the manager can adjust his guidance policy captured by the parameter g and take into account the expectations of the fundamental traders in order to influence the next period price.

Combining the different support sets, we get eighteen different coefficient estimates with corresponding entropies for each firm in the sample. The coefficients estimates with the lowest entropy for the growth and value stocks in our sample are reported in Table 4.5 respectively in Table 4.6.[3] For focus is on the coefficients g and b since according to the steady–state conditions of the problem and the assumption that $c = 1$, $a = -g$ and $h = -b$.

The estimated coefficients for the growth and value stocks are reported in Tables 4.5 and 4.6 respectively. Figures 4.1 and 4.2 illustrate the estimation results graphically.

[3]The full sample of estimates is available upon request.

Table 4.5: Coefficient Estimates for Growth Stocks

	g	b	H
AIG	-0.205	0.500	1.153
American Express	-0.282	0.227	4.197
Amgen	-0.057	0.776	3.718
Cisco	-0.057	0.776	6.015
Comcast	-0.300	0.744	6.450
Dell	-0.429	0.774	5.226
EBay	-0.282	0.227	7.841
Exxon	-0.100	0.752	1.514
Home Depot	-0.225	0.282	5.026
IBM	-0.208	0.500	3.386
J&J	-0.057	0.752	5.724
Lowe's	-0.192	0.500	6.446
Medtronic	-0.429	0.772	7.333
Oracle	-0.150	0.776	6.554
Pepsico	-0.225	0.500	6.824
P&G	-0.100	0.752	4.911
United Health	-0.434	0.752	4.833
Walgreen	-0.220	0.500	7.201
Wal Mart	-0.438	0.752	5.637
Yahoo	-0.205	0.500	3.509
Mean	-0.230	0.606	
Median	-0.214	0.748	
St.Dev.	0.127	0.196	

Table 4.6: Estimated Coefficients for Value Stocks

	g	b	H
AT&T	-0.050	0.205	3.386
Bank of America	-0.100	0.776	6.047
Bristol Myers	-0.500	1.042	3.875
Citigroup	-0.411	0.752	3.682
ConocoPhilips	-0.100	0.227	8.608
Duke Energy	-0.300	0.773	4.745
Du Pont	-0.057	0.764	4.559
Fannie Mae	-0.050	0.227	3.773
Hewlett Packert	-0.100	0.773	1.832
JPMorgan Chase	-0.196	0.500	6.565
Merck	-0.400	0.201	4.367
Merrill Lynch	-0.200	0.720	1.337
Morgan Stanley	-0.057	0.772	6.486
Motorola	-0.427	0.774	9.796
Sprint Nextel	-0.050	0.205	8.340
Time Warner	-0.050	0.213	9.461
Tyco	-0.100	0.500	7.804
Verizon	-0.057	0.776	4.319
Washington Mutual	-0.300	0.683	4.103
Wells Fargo	-0.192	0.500	8.522
Mean	-0.178	0.554	
Median	-0.100	0.702	
St.Dev.	0.154	0.280	

Figure 4.1: Estimated Guidance Policies of Growth and Value Stocks

The box portion of the boxplot represents the first and third quartiles. The median is depicted using a line through the center of the box, while the mean is drawn using a symbol. The shaded region displays approximate confidence intervals for the median. The bounds of the shaded area are defined by the median $+/-1.57 * IQR/\sqrt{N}$, where IQR is the difference between the first and third quartile and N is the number of observations.

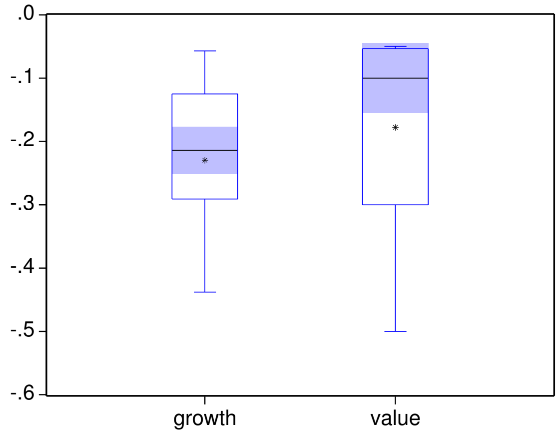


Figure 4.2: Estimated Preferences of Growth and Value Managers

The box portion of the boxplot represents the first and third quartiles. The median is depicted using a line through the center of the box, while the mean is drawn using a symbol. The shaded region displays approximate confidence intervals for the median. The bounds of the shaded area are defined by the median $+/-1.57 * IQR/\sqrt{N}$, where IQR is the difference between the first and third quartile and N is the number of observations.

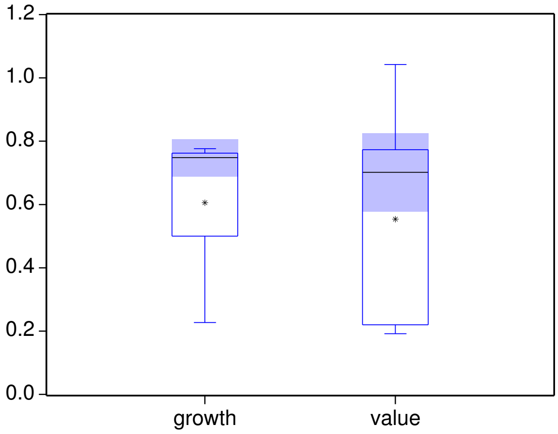


Table 4.7: Significance Tests

	g	b
F-Test (variances)	1.462	2.049
	(0.415)	(0.125)
Levene Test	1.846	6.604
	(0.1823)	(0.014)
T-Test (means)	-1.165	-0.680
	(0.126)	(0.250)
Wilcoxon Mann-Whitney Test	133.5	219.5
	(0.036)	(0.306)
Kolmogorov-Smirnov Test	0.350	0.200
	(0.076)	(0.348)

The average guidance coefficient estimated for the sample of growth firms is equal to -0.230, which is greater in absolute terms compared to the corresponding average for the sample of value firms equal to -0.178. Additionally, the standard deviation of the estimated guidance of growth firm is lower than the corresponding statistic in the value sample. These difference indicate that the growth firms guide on average stronger than value firms and the guiding policies of the growth firms is more homogenous than the guiding policies of the value firms included in our sample.

To verify the significance of this result we first apply the F–Test and the Levene Test to test the null hypothesis that the variances of both samples are homogenous. Both tests indicate that we cannot reject the null hypothesis under a reasonable level of risk. Thus, we can apply the Student t-test to derive conclusions whether the observed differences in the average estimates of both samples are statistically significant. We can reject the null hypothesis that the means of the value and growth samples of estimates are equal under the risk of 12.6%. We also apply two additional non–parametric tests to relax the assumption that the differences between the samples are normally distributed. With the Wilcoxon Mann-Whitney statistic we test whether the locations of the distribution with growth estimates is on the right side of the distribution with value estimates. We can reject the null hypothesis of identical distribution functions under the risk of 3.6%. With the Kolmogorov-Smirnov-one-tailed test we extend the analysis to compare any part of both distributions. We can reject the null-hypothesis that the distribution of estimates in the growth sample is not significantly lower than the distribution of estimates in the value sample under the risk that it is true of 7.59%. Overall, we may conclude that the heterogeneity of the guiding policies of the firms in the growth and value sample is similar, but most of the growth firms guide stronger than the value firms.

Differences between value and growth firms are also observed with respect to the managers' variance aversion. Comparing the variance of the estimated coefficients in each group, we find significant differences between the managers' preferences in the growth and value sample, i.e the group of the growth managers is more homogeneous than the group of the value managers. These managers have also a higher aversion to variances in price changes than the value stocks managers. Though, this difference is not statistically significant according to the applied non–parametric tests.

4.8 Discussion

The estimation results presented in the previous section suggest that growth firms provide stronger guidance to the analysts. In our model, the motivation for their guiding policy can either be driven by their preferences or by the power of positive feedback traders increasing the variance of firm's price changes. We do not observe significant differences in the preferences of the value and growth managers with respect to the variance of the firm's price changes. Thus, the observation that growth firms' managers guide stronger than value firms' managers can be explained with the stronger demand of positive feedback traders.

Positive feedback traders are expected to be more active in trading growth stocks because growth stocks are usually more difficult to evaluate since most of their assets are intangible. To the extent that the value and profitability of firm's assets is uncertain, investors trading the shares of the firm would be more willing to base their decisions on previous prices than on earnings forecasts of the analysts. This is, the future market price of the firm would be dominated by the expectations of the positive feedback traders and the impact of the fundamental investors would be limited. This motivates variance-averse managers to intervene against the positive feedback traders by providing stronger guidance to the analysts that in turn influence the expectations of the fundamental traders.

The managerial guidance has a significant impact on the precision and efficiency of analysts' forecasts. Our first result in section 4.4 states that the stronger the provided guidance the smaller is the analysts' forecast error, given that the current price grows in the opposite direction as the earnings drift, ceteris paribus. For example, if the current price decreases (increases) although the firm's earnings tend to increase (decrease), the manager's guidance increases the precision of the analysts' forecasts, see equation (4.12). We can use this result in the context of our estimations to derive a proposition on the relative impact of guidance on the forecast errors of analysts following value and growth stocks. If we assume that the earnings of value and growth stocks have both either a positive or a negative drift, we propose that the forecast errors of the analysts following growth firms should be lower than the forecast errors of the analysts following value firms since according to our estimates, growth managers guide stronger than value managers. Doukas, Kim and Penzalis (2002) provide empirical evidence supporting our proposition.

The estimated differences in the guiding policies of value and growth managers have additional implications for the efficiency of analysts' forecasts as stated in our second result in section 4.4. In a bull (bear) market when earnings drift and current price changes are positive (negative), stronger guidance means also a higher degree of autocorrelation of subsequent forecast errors, see equation (4.16). Hence, we can expect that the inefficiency of forecasts observed in the empirical literature would be more pronounced for analysts following growth firms than for analysts estimating the earnings of value firms. Testing this proposition is a subject of further research.

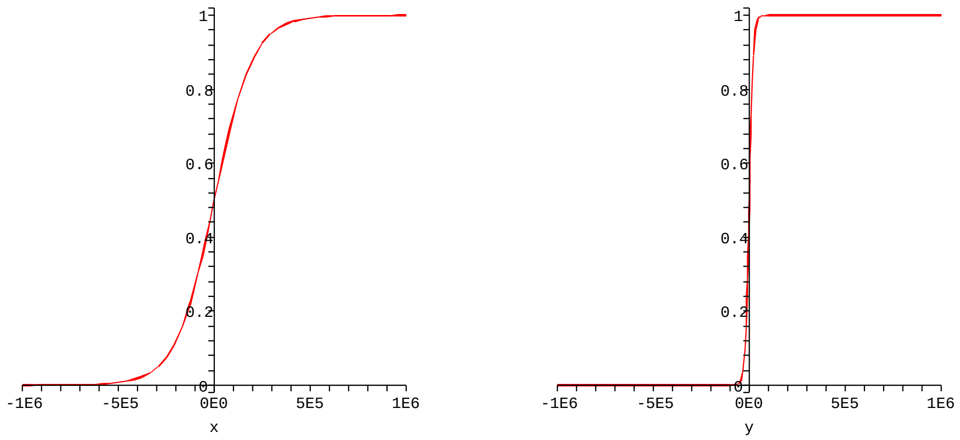
4.9 Conclusion

In this paper we estimate the guiding policy of different managers as the solution of an optimal control problem, in which managers minimize the variance of their firms' price changes. We use our model to derive conclusions on the properties of analysts' forecasts errors. In particular, we show that optimal guidance may explain why analysts' forecast errors are correlated with previous forecast errors or with past observations of the firm's performance as observed by other empirical studies. A common explanation for the observed inefficiency is that analysts underreact to new information. In our model, the inefficiency occurs as a response to guidance provided by managers minimizing the uncertainty in the firm's market prices. According to our model, the stronger the guidance provided by the manager, the stronger is the autocorrelation of the analysts' forecast errors.

The manager's guiding policy and its implications for the analysts' forecast errors are analyzed in a linear dynamic system with control. We assume that the price of firm's shares is basically determined by positive feedback traders increasing the variance of firm's price changes and fundamental investors following the forecasts of the analysts. To minimize the variance of firm's price changes, the firm's manager guides the earnings expectations of the analysts following the firm. The parameters of the manager's objective function, the state equation governing the price changes and the feedback rule are recovered simultaneously by using the GME estimating procedure. The results suggest that the managers of growth firms provide stronger guidance to the analysts than the managers of value firms since the market price of growth firms is more likely to be determined by positive feedback traders than by fundamental investors. Using this result in the context of our model, we propose that contrary to the error-in-expectations hypothesis analysts following growth stocks should have more precise forecasts than analysts following value stocks. However, we expect that due to the differences in the optimal guiding policies of value and growth firms, the forecast errors of the analysts following growth firms will exhibit stronger autocorrelation than the forecast errors of the analysts following value firms. Since the analysts operate in an economy with managers aiming to reduce the volatility in the their firm's price deviations, we may conclude that the observed autocorrelation is desirable and thus rational.

Appendix A

The non-linear function defined in equation (2.4) is visualized in the following figures.

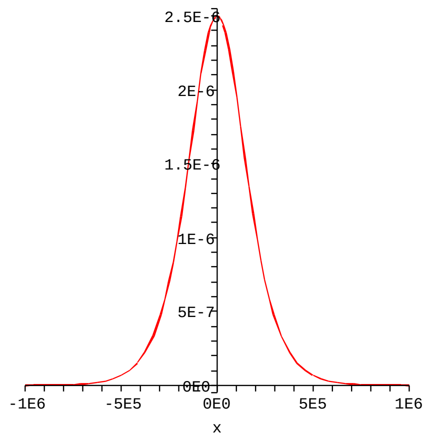


The function is plotted for values $a = 0$, $b = 0.00001$ (on the left side) and $a = 0$, $b = 0.0001$ (on the right site) and $X \in [-1'000'000; 1'000'000]$ as a reasonable range for the reported profits. Larger values of b reduce the interval, where the function takes value between zero and one. The function becomes similar to the indicator function.

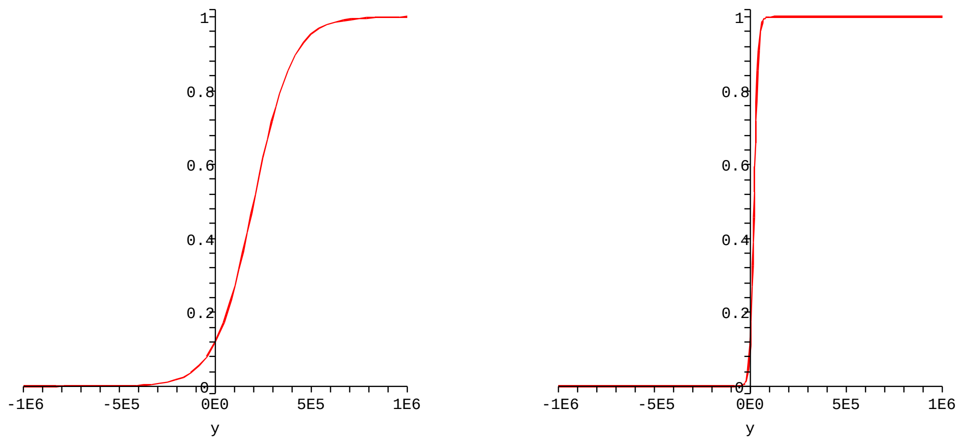
The first derivative of the function is:

$$g'(x) = \frac{b\exp(-bx)}{(1+\exp(-bx))^2} \tag{A.1}$$

It is increasing for $x < 0$ and decreasing for $x > 0$ as represented in the figure below (with $a = 0$ and $b = 0.0001$). This is equivalent to the assumption that the marginal returns of R&D investments are increasing for firms with negative profits and decreasing for firms with positive profits. This is plausible, since the pressure of firms with negative earnings to cut costs is stronger than of firms with positive profits, so that these firms have to be more careful in selecting their R&D project, which would increase the probability of success.



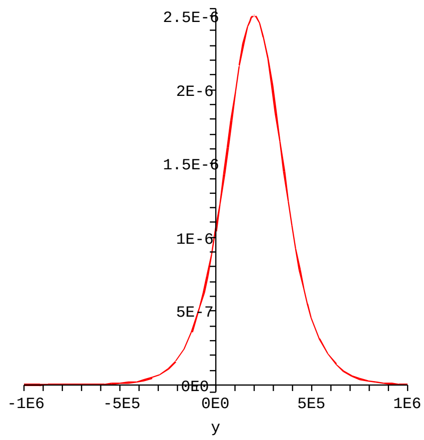
The parameter a is a shift parameter. It determines the position of the curve along the x-axis. For example. for $a = 2$ and $b = 0.00001$ respectively $b = 0.0001$, the curves look as follows.



The first derivative is then:

$$g'(x) = \frac{b\exp(a - bx)}{(1 + \exp(a - bx))^2} \tag{A.2}$$

or graphically:


2.5E-6
2E-6
1.5E-6
1E-6
5E-7
0E0
-1E6
-5E5
0E0
5E5
1E6
y

Appendix B

B.1 Proof of Theorem 1

The optimal forecasts of the analysts given their payoff function (3.7) are:

$$F_t^* = p\overline{x} + (1-p)\underline{x} + p\overline{n}^* + (1-p)\underline{n}^* \tag{B.1}$$

and

$$F_{t+1}^* = p\overline{x} + (1-p)\underline{x} - \mu\overline{n}^* - (1-\mu)\underline{n}^* \tag{B.2}$$

Then, the manager's payoff given that $x_t = \overline{x}$ is:

$$\begin{aligned} \overline{u}(.)^M &= (1-\theta)[\overline{x} + \overline{m} + \delta(p\overline{x} + (1-p)\underline{x}) - \delta\overline{n}] \\ &\quad +\delta\theta p(\overline{x} - \overline{m}) + \delta\theta(1-p)(\underline{x} - \overline{m}) \end{aligned} \tag{B.3}$$

and given that $x_t = \underline{x}$ is:

$$\begin{aligned} \underline{u}(.)^M &= (1-\theta)[\underline{x} + \underline{m} + \delta(p\overline{x} + (1-p)\underline{x}) - \delta\underline{n}] \\ &\quad +\delta\theta p(\overline{x} - \underline{m}) + \delta\theta(1-p)8\underline{x} - \underline{m}) \end{aligned} \tag{B.4}$$

Since the manager's payoff is increasing in $\overline{m}$ respectively $\underline{m}$, the manager would choose the extreme strategies $\overline{m} = \underline{m} = m_{max}$ (respectively $\overline{m} = \underline{m} = m_{min}$). If the manager is indifferent between manipulating earnings or truthful reporting, we assume that she chooses $\overline{m} = \underline{m} = 0$.

Comparing the manager's payoff associated with the different strategies we get that the manager's payoff is maximal if

$$\overline{m} = \underline{m} = m_{max} > 0 \text{ and } \theta < \frac{1}{1+\delta} \tag{B.5}$$

or

$$\overline{m} = \underline{m} = m_{min} < 0 \text{ and } \theta > \frac{1}{1+\delta} \tag{B.6}$$

If $\theta = \frac{1}{1+\delta}$, the manager is indifferent between manipulating the earnings and truthful reporting. The analysts' beliefs are correct and given these beliefs the manager does not have incentives to follow a different strategy, i.e. $\overline{m} = \overline{n} = \underline{m} = \underline{n} = 0$.

If the manager prefers to manipulate the earnings, the analysts adjust their beliefs accordingly, so that in equilibrium $\overline{m} = \underline{m} = \overline{n} = \underline{n} = m_{min}$ respectively

$\overline{m} = \underline{m} = \overline{n} = \underline{n} = m_{max}$ for any $\mu \in [0,1]$. If for example $\overline{n} = \underline{n} = m_{max}$, the manager's payoffs in both states are:

$$\begin{aligned} \overline{u}(.)^M &= (1-\theta)[\overline{x}+\overline{m}+\delta(p\overline{x}+(1-p)\underline{x}-m_{max})] \\ &\quad +\delta\theta p[\overline{x}-\overline{m}]+\delta\theta(1-p)[\underline{x}-\overline{m}] \end{aligned} \tag{B.7}$$

respectively

$$\begin{aligned} \underline{u}(.)^M &= (1-\theta)[\underline{x}+\underline{m}+\delta(p\overline{x}+(1-p)\underline{x}-m_{max})] \\ &\quad +\delta\theta p(\overline{x}-\underline{m})+\delta\theta(1-p)(\underline{x}-\underline{m}) \end{aligned} \tag{B.8}$$

Then, the manager would compare her payoffs from different manipulation strategies $m \in [m_{min}, m_{max}]$ and would choose the strategy delivering the maximum payoff. If the analysts choose $\overline{n} = \underline{n} = m_{max}$ the manager's payoff is maximal if she plays $\overline{m} = \underline{m} = m_{max}$ given that $\theta < \frac{1}{1+\delta}$. Similarly, the manager's payoff from following the strategy $\overline{m} = \underline{m} = m_{min}$ given that the analysts choose $\overline{n} = \underline{n} = m_{min}$ is maximal if $\theta > \frac{1}{1+\delta}$. If $\theta = \frac{1}{1+\delta}$, the manager is indifferent between manipulating earnings and truthful reporting and she chooses $\overline{m} = \underline{m} = 0$.

B.2 Proof of Theorem 2

Suppose that in this equilibrium the best response of the analysts is $F_t^* = F_{t+1}^* = p\overline{x}+(1-p)\underline{x}$. Later on, we are proving this claim.

Given the beliefs of the analysts, the payoffs of the manager in both states are:

$$\begin{aligned} \overline{u}^M(.) &= (1-\theta)[\overline{x}+\overline{m}+\delta(p\overline{x}+(1-p)\underline{x})+v(\overline{x}+\overline{m}-p\overline{x}-(1-p)\underline{x})] \\ &\quad +\delta\theta p[\overline{x}-\overline{m}+v(\overline{x}-\overline{m}-p\overline{x}-(1-p)\underline{x})] \\ &\quad +\delta\theta(1-p)[\underline{x}-\overline{m}+v(\underline{x}-\overline{m}-p\overline{x}-(1-p)\underline{x})] \end{aligned} \tag{B.9}$$

respectively

$$\begin{aligned} \underline{u}^M(.) &= (1-\theta)[\underline{x}+\underline{m}+\delta(p\overline{x}+(1-p)\underline{x})+v(\underline{x}+\underline{m}-p\overline{x}-(1-p)\underline{x})] \\ &\quad +\delta\theta p[\overline{x}-\underline{m}+v(\overline{x}-\underline{m}-p\overline{x}-(1-p)\underline{x})] \\ &\quad +\delta\theta(1-p)[\underline{x}-\underline{m}+v(\underline{x}-\underline{m}-p\overline{x}-(1-p)\underline{x})] \end{aligned} \tag{B.10}$$

Now, we consider different levels of manipulation for which the marginal utility change and compare the manager's payoffs associated with them. For $F_t^* = F_{t+1}^* = p\overline{x}+(1-p)\underline{x}$ the manipulation decisions changing the marginal utility of manipulation are:

$$\begin{aligned} \overline{m}_1 &= m_{min} \\ \overline{m}_2 &= \underline{x}-p\overline{x}-(1-p)\underline{x} = -p(\overline{x}-\underline{x}) \\ \overline{m}_3 &= p\overline{x}+(1-p)\underline{x}-\overline{x} = -(1-p)(\overline{x}-\underline{x}) \\ \overline{m}_4 &= 0 \\ \overline{m}_5 &= \overline{x}-p\overline{x}-(1-p)\underline{x} = (1-p)(\overline{x}-\underline{x}) \\ \overline{m}_6 &= m_{max} \end{aligned} \tag{B.11}$$

(B.12)

respectively

$$\begin{aligned}
\underline{m}_1 &= m_{min} \\
\underline{m}_2 &= \underline{x} - p\overline{x} - (1-p)\underline{x} = -p(\overline{x} - \underline{x}) \\
\underline{m}_3 &= 0 \\
\underline{m}_4 &= \overline{x} - p\overline{x} - (1-p)\underline{x} = (1-p)(\overline{x} - \underline{x}) \\
\underline{m}_5 &= p\overline{x} - (1-p)\underline{x} - \underline{x} = p(\overline{x} - \underline{x}) \\
\underline{m}_6 &= m_{max}
\end{aligned} \tag{B.13}$$

(B.14)

Thus, to prove that the manipulation strategies $\overline{m}_3 = -(1-p)(\overline{x} - \underline{x})$ and $\underline{m}_5 = p(\overline{x} - \underline{x})$ are the best given that $F_t^* = F_{t+1}^* = p\overline{x} + (1-p)\underline{x}$ we need to prove that the manager cannot increase her payoff by following a different strategy given the beliefs of the analysts. To define the conditions for which this is true, we compare the manager's payoffs associated with the different manipulation strategies.

Consider first the case where $x_t = \overline{x}$. Then, the manager's payoffs associated with the manipulation strategies changing the marginal utility of manipulation in this state are:

$$\begin{aligned}
\overline{u}_1^M(\overline{m} = m_{min}) = \; & (1-\theta)[\overline{x} + m_{min} + \delta(p\overline{x} + (1-p)\underline{x}) \\
& + \beta(\overline{x} + m_{min} - p\overline{x} - (1-p)\underline{x})] \\
& + \delta\theta p(\overline{x} - m_{min} + \overline{x} - m_{min} - p\overline{x} - (1-p)\underline{x}) \\
& + \delta\theta(1-p)[\underline{x} - m_{min} + \underline{x} - m_{min} - p\overline{x} - (1-p)\underline{x}]
\end{aligned} \tag{B.15}$$

$$\begin{aligned}
\overline{u}_2^M(\overline{m} = -p(\overline{x} - \underline{x})) = \; & (1-\theta)[\overline{x} - p(\overline{x} - \underline{x}) + \delta(p\overline{x} + (1-p)\underline{x}) \\
& + \beta(\overline{x} - p(\overline{x} - \underline{x}) - p\overline{x} - (1-p)\underline{x})] \\
& + \delta\theta p(\overline{x} + p(\overline{x} - \underline{x}) + \overline{x} + p(\overline{x} - \underline{x}) - p\overline{x} - (1-p)\underline{x}) \\
& + \delta\theta(1-p)(\underline{x} + p(\overline{x} - \underline{x}))
\end{aligned} \tag{B.16}$$

$$\begin{aligned}
\overline{u}_3^M(\overline{m} = -(1-p)(\overline{x} - \underline{x})) = \; & (1-\theta)[\overline{x} - (1-p)(\overline{x} - \underline{x}) + \delta(p\overline{x} + (1-p)\underline{x})] \\
& + \delta\theta p[\overline{x} + (1-p)(\overline{x} - \underline{x}) \\
& + \overline{x} + (1-p)(\overline{x} - \underline{x}) - p\overline{x} - (1-p)\underline{x}] \\
& + \delta\theta(1-p)[\underline{x} + (1-p)(\overline{x} - \underline{x}) \\
& + \beta(\underline{x} + (1-p)(\overline{x} - \underline{x}) - p\overline{x} - (1-p)\underline{x})]
\end{aligned} \tag{B.17}$$

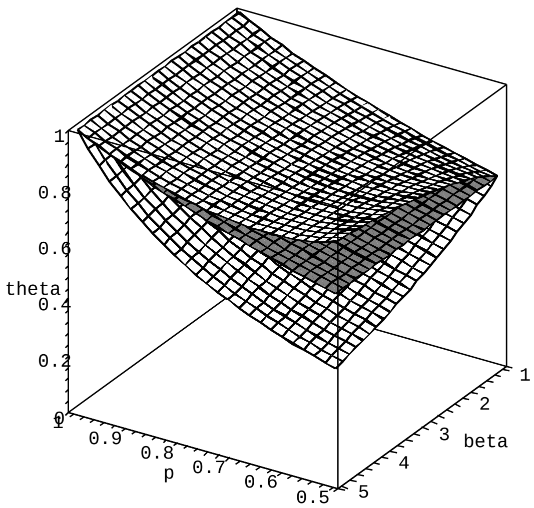
$$\begin{aligned}
\overline{u}_4^M(\overline{m} = 0) = \; & (1-\theta)[\overline{x} + \delta(p\overline{x} + (1-p)\underline{x}) + \overline{x} - p\overline{x} - (1-p)\underline{x}] \\
& + \delta\theta p[\overline{x} + \overline{x} - p\overline{x} - (1-p)\underline{x}] \\
& + \delta\theta(1-p)[\underline{x} + \beta(\underline{x} - p\overline{x} - (1-p)\underline{x})]
\end{aligned} \tag{B.18}$$

$$
\begin{aligned}
\overline{u}_5^M(\overline{m} = (1-p)(\overline{x}-\underline{x})) \quad = \quad & (1-\theta)[\overline{x} + (1-p)(\overline{x}-\underline{x}) + \delta(p\overline{x} + (1-p)\underline{x}) \\
& +\overline{x} + (1-p)(\overline{x}-\underline{x}) - p\overline{x} - (1-p)\underline{x}] \\
& +\delta\theta p[\overline{x} - (1-p)(\overline{x}-\underline{x})] \\
& +\delta\theta(1-p)[\underline{x} - (1-p)(\overline{x}-\underline{x}) \\
& +\beta(\underline{x} - (1-p)(\overline{x}-\underline{x}) - p\overline{x} - (1-p)\underline{x})]
\end{aligned} \tag{B.19}
$$

$$
\begin{aligned}
\overline{u}_6^M(\overline{m} = m_{max}) \quad = \quad & (1-\theta)[\overline{x} + m_{max} + \delta(p\overline{x} + (1-p)\underline{x}) \\
& +\overline{x} + m_{max} - p\overline{x} - (1-p)\underline{x}] \\
& +\delta\theta p[\overline{x} - m_{max} + \beta(\overline{x} - m_{max} - p\overline{x} - (1-p)\underline{x})] \\
& +\delta\theta(1-p)[\underline{x} - m_{max} + \beta(\underline{x} - m_{max} - p\overline{x} - (1-p)\underline{x})]
\end{aligned} \tag{B.20}
$$

The strategy $\overline{m}_3 = -(1-p)(\overline{x}-\underline{x})$ is optimal for the managers if (B.17) is larger than (B.15), (B.16), (B.18), (B.19) and (B.20). We derive conditions on θ depending on the parameters p, δ and β for which this is true. These conditions are illustrated in Figure B.1 as manifolds under the assumption that $\delta = 0.95$ and $m_{max} = 2\overline{x}$.

Figure B.1: Restrictions on θ satisfying the equilibrium conditions for the case $x_t = \overline{x}$



The two-dimensional manifolds determine the subsets of parameters for which certain payoffs are equal. The subset of parameters under the top manifold are such that (B.17) is greater than (B.15). The subset of parameters under the middle manifold are such that (B.17) is greater than (B.16). The subset of parameters above the lowest manifold are such that (B.17) is greater than (B.18), (B.19) and (B.20).

Thus, the upper bound of the parameter θ is determined by the condition that

(B.17) is lower than (B.16) and the lower bound of the parameter θ is determined by the condition that (B.17) is greater than (B.18). This is equivalent to the condition

$$\frac{2}{2+\delta(1+p)+\delta\beta(1-p)} \leq \theta \leq \frac{1+\beta}{(1+\beta)(1+\delta)+\delta p(1-\beta)} \tag{B.21}$$

Consider next the case, where $x_t = \underline{x}$. Then, the manager's payoffs associated with the manipulation strategies in this state are:

$$\begin{aligned} \underline{u}_1^M(\underline{m} = m_{min}) \;&=\; (1-\theta)[\underline{x}+m_{min}+\delta(p\overline{x}+(1-p)\underline{x}) \\ &\quad +\beta(\underline{x}+m_{min}-p\overline{x}-(1-p)\underline{x})] \\ &\quad +\delta\theta p(\overline{x}-m_{min}+\overline{x}-m_{min}-p\overline{x}-(1-p)\underline{x}) \\ &\quad +\delta\theta(1-p)(\underline{x}-m_{min}+\underline{x}-m_{min}-p\overline{x}-(1-p)\underline{x}) \end{aligned} \tag{B.22}$$

$$\begin{aligned} \underline{u}_2^M(\underline{m} = -p(\overline{x}-\underline{x})) \;&=\; (1-\theta)[\underline{x}-p(\overline{x}-\underline{x})+\delta(p\overline{x}+(1-p)\underline{x}) \\ &\quad +\beta(\underline{x}-p(\overline{x}-\underline{x})-p\overline{x}-(1-p)\underline{x})] \\ &\quad +\delta\theta p[\overline{x}+p(\overline{x}-\underline{x})+\overline{x}+p(\overline{x}-\underline{x})-p\overline{x}-(1-p)\underline{x}] \\ &\quad +\delta\theta(1-p)[\underline{x}+p(\overline{x}-\underline{x})] \end{aligned} \tag{B.23}$$

$$\begin{aligned} \underline{u}_3^M(\underline{m} = 0) \;&=\; (1-\theta)[\underline{x}+\delta(p\overline{x}+(1-p)\underline{x})+\beta(\underline{x}-p\overline{x}-(1-p)\underline{x})] \\ &\quad +\delta\theta p(\overline{x}+\overline{x}-p\overline{x}-(1-p)\underline{x}) \\ &\quad +\delta\theta(1-p)[\underline{x}+\beta(\underline{x}-p\overline{x}-(1-p)\underline{x})] \end{aligned} \tag{B.24}$$

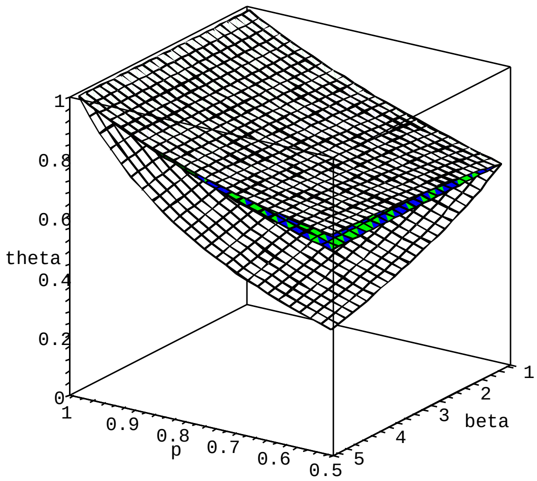
$$\begin{aligned} \underline{u}_4^M(\underline{m} = (1-p)(\overline{x}-\underline{x})) \;&=\; (1-\theta)[\underline{x}+(1-p)(\overline{x}-\underline{x})+\delta(p\overline{x}+(1-p)\underline{x}) \\ &\quad +\beta(\underline{x}+(1-p)(\overline{x}-\underline{x})-p\overline{x}-(1-p)\underline{x})] \\ &\quad +\delta\theta p[\overline{x}-(1-p)(\overline{x}-\underline{x})+\overline{x}] \\ &\quad +\delta\theta(1-p)[\underline{x}-(1-p)(\overline{x}-\underline{x}) \\ &\quad +\beta(\underline{x}-(1-p)(\overline{x}-\underline{x})-p\overline{x}-(1-p)\underline{x})] \end{aligned} \tag{B.25}$$

$$\begin{aligned} \underline{u}_5^M(\underline{m} = p(\overline{x}-\underline{x})) \;&=\; (1-\theta)[\underline{x}+p(\overline{x}-\underline{x})+\delta(p\overline{x}+(1-p)\underline{x}) \\ &\quad +\delta\theta p[\overline{x}-p(\overline{x}-\underline{x})+\beta(\overline{x}-p(\overline{x}-\underline{x})-p\overline{x}-(1-p)\underline{x})] \\ &\quad +\delta\theta(1-p)[\underline{x}-p(\overline{x}-\underline{x})] \\ &\quad +\delta\theta(1-p)[\beta(\underline{x}-p(\overline{x}-\underline{x})-p\overline{x}-(1-p)\underline{x})] \end{aligned} \tag{B.26}$$

$$\begin{aligned}\underline{u}_6^M(\underline{m} = m_{max}) &= (1-\theta)[\underline{x} + m_{max} + \delta(p\overline{x} + (1-p)\underline{x}) \\ &\quad + \underline{x} + m_{max} - p\overline{x} - (1-p)\underline{x}] \\ &\quad + \delta\theta p[\overline{x} - m_{max} + \beta(\overline{x} - m_{max} - p\overline{x} - (1-p)\underline{x})] \\ &\quad + \delta\theta(1-p)[\underline{x} - m_{max}] \\ &\quad + \delta\theta(1-p)[\underline{x} - m_{max} - p\overline{x} - (1-p)\underline{x}]\end{aligned} \tag{B.27}$$

The strategy $\underline{m}_5 = p(\overline{x} - \underline{x})$ is optimal for the manager if (B.26) is larger than (B.22), (B.23), (B.24), (B.25) and (B.27). We derive conditions on θ depending on the parameters p, δ and β for which this is true. These conditions are illustrated in Figure B.2 as manifolds under the assumption that $\delta = 0.95$ and $m_{max} = 2\overline{x}$.

Figure B.2: Restrictions on θ satisfying the equilibrium conditions for the case $x_t = \underline{x}$



The two-dimensional manifolds determine the subsets of parameters for which certain payoffs are equal. The subset of parameters under the top manifold are such that (B.26) is greater than (B.22). The subset of parameters under the middle manifold are such that (B.26) is greater than (B.23), (B.24) and (B.25). The subset of parameters above the lowest manifold are such that (B.26) is greater than (B.27).

Thus, the strategy $\underline{m}_5 = p(\overline{x} - \underline{x})$ is optimal for the manager if (B.26) is larger than (B.24) and (B.27). This is true for

$$\frac{-2(m_{max} - p(\overline{x} - \underline{x}))}{2p + \delta p(1+\beta) - m_{max}(2 + \delta(1+\beta))} \leq \theta \leq \frac{1}{1+\delta} \tag{B.28}$$

If $m_{max} = \overline{x} - \underline{x}$ for example, then the condition is equivalent to:

$$\frac{2}{2 + \delta(1+\beta)} \leq \theta \leq \frac{1}{1+\delta} \tag{B.29}$$

Comparing the conditions (B.21) and (B.29), one can see that the lower bound for the parameter θ is determined by condition (B.21) and the upper bound for the parameter θ is determined by condition (B.29) so that for $\frac{2}{2+\delta(1+p)+\delta\beta(1-p)} \leq \theta \leq \frac{1}{1+\delta}$ the best strategy of the manager is to cover the consensus forecast, which is equal to the mean of the "true" earnings in this equilibrium.

Note that this strategy is optimal only if investors are loss averse. For $\beta \leq 1$ the conditions (B.21) and (B.29) are empty and the non–revealing equilibrium where the manager manipulates earnings to meet the consensus forecast would not exist.

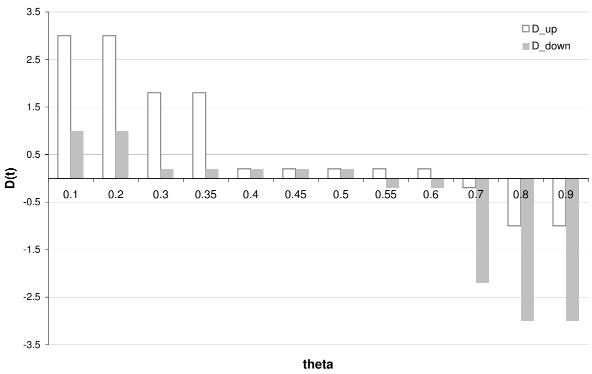
Finally, we prove that given the best response of the manager, the best forecasts of the analysts is $F_t = \overline{F}_{t+1} = \underline{F}_{t+1} = p\overline{x} + (1-p)\underline{x}$. The optimal forecasts of the analysts given their payoff function (3.7) and the optimal manipulation decision of the manager are:

$$\begin{aligned} F_t^* = \overline{F}_{t+1}^* &= \underline{F}_{t+1}^* \\ &= p\overline{x} + (1-p)\underline{x} + p(1-p)(\underline{x} - \overline{x}) + (1-p)p(\overline{x} - \underline{x}) \\ &= p\overline{x} + (1-p)\underline{x} \end{aligned} \tag{B.30}$$

since in this equilibrium $\mu = p$.

The optimal reporting strategy of the manager given that $F_t = F_{t+1} = p\overline{x} + (1-p)\underline{x}$ is summarized graphically using a numerical example with $\overline{x} = 1$, $\underline{x} = -1$, $p = 0.6$, $\delta = 0.95$.

Figure B.3: Optimal Reporting if $x_t = \overline{x}$ and $x_t = \underline{x}$



The figure summarizes the optimal reported earnings "D up" equal to $\overline{D}_t = \overline{x} + \overline{m}$ and "D down" equal to $\underline{D}_t = \underline{x} + \underline{m}$ given that $F_t = F_{t+1} = p\overline{x} + (1-p)\underline{x}$. The manager's optimal reporting is calculated for $\overline{x} = 1$, $\underline{x} = -1$, $\beta = 5$, $p = 0.6$, $\delta = 0.95$.

As one can easily see, the optimal manipulation strategy where $\overline{D}_t = \underline{D}_t$ results only for particular values of θ. the upper and lower bound for θ are calculated above. For other values of θ $\overline{D}_t$ is not equal to $\underline{D}_t$, so that the reporting is revealing in the sense that the analysts would adjust their beliefs in equilibrium. The chosen reporting might not be optimal anymore.

B.3 Proof of Theorem 3

Suppose that in the first equilibrium the best response of the analysts is $F_t = p\overline{x} + (1-p)\underline{x} + m_{max}$ and $\overline{F}_{t+1} = \underline{F}_{t+1} = p\overline{x} + (1-p)\underline{x} - m_{max}$. later on, we are proving this claim.
Given the beliefs of the analysts, the manager's payoffs are:

$$\begin{aligned} \overline{u}^M(.) \;=\; & (1-\theta)[\overline{x} + \overline{m} + \delta(p\overline{x} + (1-p)\underline{x} - m_{max})] \\ & + (1-\theta)[v(\overline{x} + \overline{m} - p\overline{x} - (1-p)\underline{x} + m_{max})] \\ & + \delta\theta p[\overline{x} - \overline{m} + v(\overline{x} - \overline{m} - p\overline{x} - (1-p)\underline{x} + m_{max})] \\ & + \delta\theta(1-p)[\underline{x} - \overline{m} + v(\underline{x} - \overline{m} - p\overline{x} - (1-p)\underline{x} + m_{max})] \end{aligned} \tag{B.31}$$

respectively

$$\begin{aligned} \underline{u}^M(.) \;=\; & (1-\theta)[\underline{x} + \underline{m} + \delta(p\overline{x} + (1-p)\underline{x} - m_{max})] \\ & + (1-\theta)[v(\underline{x} + \underline{m} - p\overline{x} - (1-p)\underline{x} + m_{max})] \\ & + \delta\theta p[\overline{x} - \underline{m} + v(\overline{x} - \underline{m} - p\overline{x} - (1-p)\underline{x} + m_{max})] \\ & + \delta\theta(1-p)[\underline{x} - \underline{m} + v(\underline{x} - \underline{m} - p\overline{x} - (1-p)\underline{x} + m_{max})] \end{aligned} \tag{B.32}$$

Now, we consider different levels of manipulation for which the marginal utility of manipulation changes and compare the manager's payoff associated with them. Given the analysts' forecasts representing the reference point in the function $v(.)$ the feasible manipulation levels $m \in [m_{min}, m_{max}]$ for which the marginal utility of manipulation changes are:

$$\begin{aligned} \overline{m} &= m_{max} - \overline{x} + p\overline{x} + (1-p)\underline{x} \qquad \text{(B.33)} \\ \overline{m} &= m_{max} + \underline{x} - p\overline{x} - (1-p)\underline{x} \\ \underline{m} &= m_{max} + \underline{x} - p\overline{x} - (1-p)\underline{x} \end{aligned}$$

Note that given the analysts' forecasts, the manager is able to meet them in the current period only if $x_t = \overline{x}$. If $x_t = \underline{x}$, the manipulation required to meet the consensus forecast is not feasible since we assume that $m \in [m_{min}, m_{max}]$.

Overall, the manager can chose among the following strategies:

$$\begin{aligned} \overline{m}_1 &= m_{min} \\ \overline{m}_2 &= 0 \\ \overline{m}_3 &= m_{max} + \underline{x} - p\overline{x} - (1-p)\underline{x} \\ \overline{m}_4 &= m_{max} - \overline{x} + p\overline{x} + (1-p)\underline{x} \\ \overline{m}_5 &= m_{max} \end{aligned}$$

respectively

$$\begin{aligned} \underline{m}_1 &= m_{min} \\ \underline{m}_2 &= 0 \\ \underline{m}_3 &= m_{max} + \underline{x} - p\overline{x} - (1-p)\underline{x} \\ \underline{m}_4 &= m_{max} \end{aligned}$$

Consider first the case where $x_t = \overline{x}$. The manager's payoffs associated with the manipulation strategies listed above are as follows.

$$\begin{aligned}
\overline{u}_1^M(.) &= (1-\theta)[\overline{x}+m_{min}+\delta(p\overline{x}+(1-p)\underline{x}-m_{max}) \\
&\quad +\beta(\overline{x}+m_{min}-p\overline{x}-(1-p)\underline{x}-m_{max})] \\
&\quad +\delta\theta p[\overline{x}-m_{min}+\overline{x}-m_{min}-p\overline{x}-(1-p)\underline{x}+m_{max}] \\
&\quad +\delta\theta(1-p)[\underline{x}-m_{min}+\underline{x}-m_{min}-p\overline{x}-(1-p)\underline{x}+m_{max}]
\end{aligned} \tag{B.34}$$

$$\begin{aligned}
\overline{u}_2^M(.) &= (1-\theta)[\overline{x}+\delta(p\overline{x}+(1-p)\underline{x}-m_{max}) \\
&\quad +\beta(\overline{x}-p\overline{x}-(1-p)\underline{x}-m_{max})] \\
&\quad +\delta\theta p[\overline{x}+\overline{x}-p\overline{x}-(1-p)\underline{x}+m_{max}] \\
&\quad +\delta\theta(1-p)[\underline{x}+\underline{x}-p\overline{x}-(1-p)\underline{x}+m_{max}]
\end{aligned} \tag{B.35}$$

$$\begin{aligned}
\overline{u}_3^M(.) &= (1-\theta)[\overline{x}+m_{max}+\underline{x}-p\overline{x}-(1-p)\underline{x}+\delta(p\overline{x}+(1-p)\underline{x}-m_{max}) \\
&\quad +\beta(\overline{x}+m_{max}+\underline{x}-p\overline{x}-(1-p)\underline{x}-p\overline{x}-(1-p)\underline{x}-m_{max})] \\
&\quad +\delta\theta p[\overline{x}-m_{max}-\underline{x}+p\overline{x}+(1-p)\underline{x} \\
&\quad +\overline{x}-m_{max}-\underline{x}+p\overline{x}+(1-p)\underline{x}-p\overline{x}-(1-p)\underline{x}+m_{max}] \\
&\quad +\delta\theta(1-p)[\underline{x}-m_{max}-\underline{x}+p\overline{x}+(1-p)\underline{x}]
\end{aligned} \tag{B.36}$$

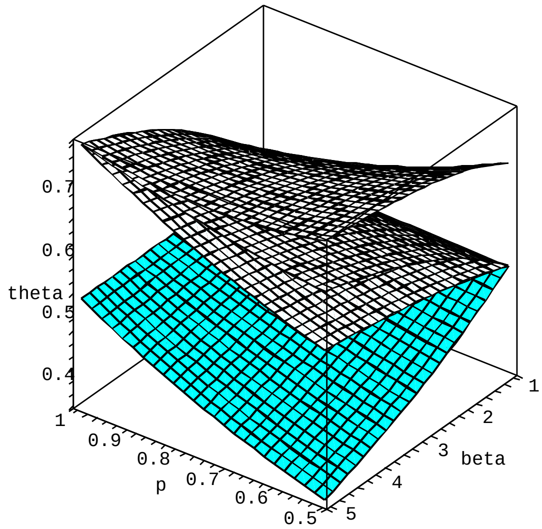
$$\begin{aligned}
\overline{u}_4^M(.) &= (1-\theta)[\overline{x}+m_{max}-\overline{x}+p\overline{x}+(1-p)\underline{x}+\delta(p\overline{x}+(1-p)\underline{x}-m_{max})] \\
&\quad +\delta\theta p[\overline{x}-m_{max}+\overline{x}-p\overline{x}-(1-p)\underline{x} \\
&\quad +\overline{x}-m_{max}+\overline{x}-p\overline{x}-(1-p)\underline{x}-p\overline{x}-(1-p)\underline{x}+m_{max}] \\
&\quad +\delta\theta(1-p)[\underline{x}-m_{max}+\overline{x}-p\overline{x}-(1-p)\underline{x} \\
&\quad +\beta(\underline{x}-m_{max}+\overline{x}-p\overline{x}-(1-p)\underline{x}-p\overline{x}-(1-p)\underline{x}+m_{max})]
\end{aligned} \tag{B.37}$$

$$\begin{aligned}
\overline{u}_5^M(.) &= (1-\theta)[\overline{x}+m_{max}+\delta(p\overline{x}+(1-p)\underline{x}-m_{max}) \\
&\quad +\overline{x}+m_{max}-p\overline{x}-(1-p)\underline{x}-m_{max}] \\
&\quad +\delta\theta p[\overline{x}-m_{max}+\overline{x}-m_{max}-p\overline{x}-(1-p)\underline{x}+m_{max}] \\
&\quad +\delta\theta(1-p)[\underline{x}-m_{max}+\beta(\underline{x}-m_{max}-p\overline{x}-(1-p)\underline{x}+m_{max})]
\end{aligned} \tag{B.38}$$

The strategy $\overline{m}_5 = m_{max}$ is optimal for the manager if (B.38) is larger than (B.34), (B.35), (B.36) and (B.37). We derive conditions on θ depending on the parameters

p, δ and β for which this is true and represent them as manifolds in the following figure.

Figure B.4: Restrictions on θ satisfying the equilibrium conditions for the case $x_t = \overline{x}$



The two-dimensional manifolds determine the subsets of parameters for which certain payoffs are equal. The subset of parameters under the top manifold is such that (B.38) is larger than (B.36). The subset of parameters under the next two manifolds is such that (B.38) is larger than (B.34) respectively (B.35). The subset of parameters under the last manifold is such that (B.38) is larger than (B.37).

As one can easily see in the figure above only condition (B.37) is binding so that the upper bound is determined by the condition that (B.38) is larger than (B.37). This is true for $\theta \in [0, \frac{2}{2+\delta(1+p)+\delta\beta(1-p)})$.

The condition on θ for which the manager follows $\underline{m} = m_{max}$ achieve the highest utility is not binding.

Suppose now that the best forecasts of the analysts in the second equilibrium are $F_t^* = p\overline{x} + (1-p)\underline{x} + m_{min}$ and $\overline{F}_{t+1}^* = \underline{F}_{t+1}^* = p\overline{x} + (1-p)\underline{x} - m_{min}$. Later on, we are proving this.

Given the analysts' forecasts, the manager can chose between the following strategies:

$$\begin{aligned}
\underline{m}_1 &= m_{min} \\
\underline{m}_2 &= m_{min} + \overline{x} - p\overline{x} - (1-p)\underline{x} \\
\underline{m}_3 &= m_{min} - \underline{x} + p\overline{x} + (1-p)\underline{x} \\
\underline{m}_4 &= 0 \\
\underline{m}_5 &= m_{max}
\end{aligned}$$

respectively

$$
\begin{aligned}
\overline{m}_1 &= m_{min} \\
\overline{m}_2 &= m_{min} + \overline{x} - p\overline{x} - (1-p)\underline{x} \\
\overline{m}_3 &= 0 \\
\underline{m}_4 &= m_{max}
\end{aligned}
$$

Consider first the case where $x_t = \underline{x}$. The payoffs from following the strategies $\underline{m}_1$ to $\underline{m}_5$ are the following:

$$
\begin{aligned}
\underline{u}_1^M(.) = {} & (1-\theta)[\underline{x} + m_{min} + \delta(p\overline{x} + (1-p)\underline{x} - m_{min}) \\
& + \beta(\underline{x} + m_{min} - p\overline{x} - (1-p)\underline{x} - m_{min})] \\
& + \delta\theta p[\overline{x} - m_{min} + \overline{x} - m_{min} - p\overline{x} - (1-p)\underline{x} + m_{min}] \\
& + \delta\theta(1-p)[\underline{x} - m_{min} + \beta(\underline{x} - m_{min} - p\overline{x} - (1-p)\underline{x} + m_{min})]
\end{aligned} \tag{B.39}
$$

$$
\begin{aligned}
\underline{u}_2^M(.) = {} & (1-\theta)[\underline{x} + m_{min} + \overline{x} - p\overline{x} - (1-p)\underline{x} + \delta(p\overline{x} + (1-p)\underline{x} - m_{min}) \\
& + \beta(\underline{x} + m_{min} + \overline{x} - p\overline{x} - (1-p)\underline{x} - p\overline{x} - (1-p)\underline{x} - m_{min})] \\
& + \delta\theta p[\overline{x} - m_{min} - \overline{x} + p\overline{x} + (1-p)\underline{x}] \\
& + \delta\theta(1-p)[\underline{x} - m_{min} - \underline{x} + p\overline{x} + (1-p)\underline{x} \\
& + \beta(\underline{x} - m_{min} - \overline{x} + p\overline{x} + (1-p)\underline{x} - p\overline{x} - (1-p)\underline{x} + m_{min})]
\end{aligned} \tag{B.40}
$$

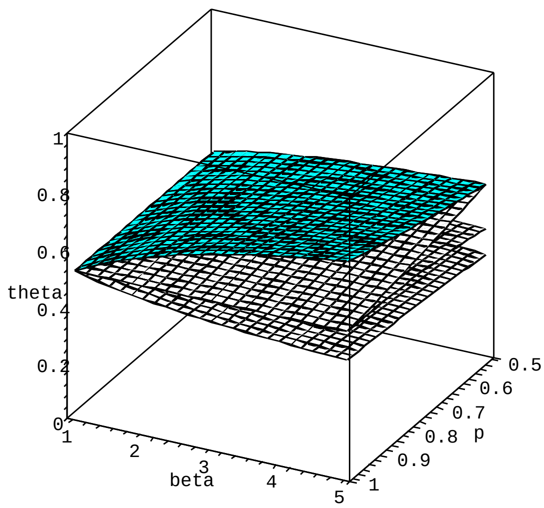
$$
\begin{aligned}
\underline{u}_3^M(.) = {} & (1-\theta)[\underline{x} + m_{min} - \underline{x} + p\overline{x} + (1-p)\underline{x} + \delta(p\overline{x} + (1-p)\underline{x} - m_{min})] \\
& + \delta\theta p[\overline{x} + \underline{x} - p\overline{x} - (1-p)\underline{x} + m_{min} \\
& + \beta(\overline{x} + \underline{x} - p\overline{x} - (1-p)\underline{x} + m_{min} - p\overline{x} - (1-p)\underline{x} + m_{min})] \\
& + \delta\theta(1-p)[\underline{x} - + \underline{x} - p\overline{x} - (1-p)\underline{x} + m_{min} \\
& + \beta(\underline{x} + \underline{x} - p\overline{x} - (1-p)\underline{x} + m_{min} - p\overline{x} - (1-p)\underline{x} + m_{min})]
\end{aligned} \tag{B.41}
$$

$$
\begin{aligned}
\underline{u}_4^M(.) = {} & (1-\theta)[\underline{x} + \delta(p\overline{x} + (1-p)\underline{x} - m_{min}) \\
& + \underline{x} - p\overline{x} - (1-p)\underline{x} - m_{min}] \\
& + \delta\theta p[\overline{x} + \beta(\overline{x} - p\overline{x} - (1-p)\underline{x} + m_{min}] \\
& + \delta\theta(1-p)[\underline{x} - m_{min} + \beta(\underline{x} - p\overline{x} - (1-p)\underline{x} + m_{min})]
\end{aligned} \tag{B.42}
$$

$$
\begin{aligned}
\underline{u}_5^M(.) \quad = \quad & (1-\theta)[\underline{x}+m_{max}+\delta(p\overline{x}+(1-p)\underline{x}-m_{min}) \\
& +\underline{x}+m_{max}-p\overline{x}-(1-p)\underline{x}-m_{min}] \\
& +\delta\theta p[\overline{x}-m_{max}+\beta(\overline{x}-m_{max}-p\overline{x}-(1-p)\underline{x}+m_{min})] \\
& +\delta\theta(1-p)[\underline{x}-m_{max}+\beta(\underline{x}-m_{max}-p\overline{x}-(1-p)\underline{x}+m_{min})]
\end{aligned} \tag{B.43}
$$

The strategy $\underline{m}=m_{min}$ is optimal for the manager, if the payoff (B.39) is larger than the payoffs (B.40), (B.41), (B.42) and (B.43). We derive conditions on θ depending on the parameters p, β and δ for which this is true and illustrate them in the following figure.

Figure B.5: Restrictions on θ satisfying the equilibrium conditions for the case $x_t=\underline{x}$



The manifolds determine the subsets of parameters for which certain payoffs are equal. The subset of parameters above the lowest manifold is such that (B.39) is larger than (B.43). The subset of parameters above the next two manifolds is such that (B.39) is larger than (B.42) respectively (B.41). The subset of parameters above the manifolds on the top is such that (B.39) is larger than (B.40).

As one can easily see in the figure above, the lower bound for the parameter θ is determined by the condition that (B.39) is larger than (B.40), which is true for $\theta \in (\frac{1+\beta}{(1+\beta)(1+\delta)+\delta p(1-\beta)}, 1]$.

The manager's payoff is maximal if she decides to manipulate earnings down to $\underline{m}=m_{min}$ if (B.39) is larger than (B.40). If this condition is satisfied, the manager would chose $\overline{m}=m_{min}$.

Given the manager's strategy $\underline{m}=\overline{m}=m_{min}$ respectively $\underline{m}=\overline{m}=m_{max}$ the best response of the analysts minimizing the squared mean forecast error as defined in

(3.7) is:

$$F_t^* = p\overline{x} + (1-p)\underline{x} + p\overline{n}^* + (1-p)\underline{n}^* = p\overline{x} + (1-p)\underline{x} + m_{min} \tag{B.44}$$

respectively

$$F_t^* = p\overline{x} + (1-p)\underline{x} + p\overline{n}^* + (1-p)\underline{n}^* = p\overline{x} + (1-p)\underline{x} + m_{max} \tag{B.45}$$

and

$$F_{t+1}^* = p\overline{x} + (1-p)\underline{x} + \mu\overline{n}^* + (1-\mu)\underline{n}^* = p\overline{x} + (1-p)\underline{x} - m_{min} \tag{B.46}$$

respectively

$$F_{t+1}^* = p\overline{x} + (1-p)\underline{x} + \mu\overline{n}^* + (1-\mu)\underline{n}^* = p\overline{x} + (1-p)\underline{x} - m_{max} \tag{B.47}$$

B.4 Proof of Theorem 4

If $v(.) = 0$, the manager's payoffs in both states are:

$$\begin{aligned} \overline{u}^M(.) &= (1-\theta)\max(\overline{x} + \overline{m} + \delta F_{t+1} - X, 0) \\ &\quad + \delta\theta p \max(\overline{x} - \overline{m} - X, 0) \\ &\quad + \delta\theta(1-p)\max(\underline{x} - \overline{m} - X, 0) \end{aligned} \tag{B.48}$$

respectively

$$\begin{aligned} \underline{u}^M(.) &= (1-\theta)\max(\underline{x} + \underline{m} + \delta F_{t+1} - X, 0) \\ &\quad + \delta\theta p \max(\overline{x} - \underline{m} - X, 0) \\ &\quad + \delta\theta(1-p)\max(\underline{x} - \underline{m} - X, 0) \end{aligned} \tag{B.49}$$

where $X := p\overline{x} + (1-p)\underline{x}$.

Consider first the case $x_t = \overline{x}$ where the manager aims to find some $\overline{m} \in [m_{min}, m_{max}]$ that maximizes (B.48) given F_{t+1}. Suppose that in this equilibrium $F_{t+1}^* = X = p\overline{x} + (1-p)\underline{x}$. Then, the manager's marginal utility would change when the manager switches between the following strategies:

$$\begin{aligned} \overline{m}_1 &= m_{min} \\ \overline{m}_2 &= \underline{x} - X \\ \overline{m}_3 &= p\overline{x} + (1-p)\underline{x} - \overline{x} \\ \overline{m}_4 &= X - \delta(\overline{x} + (1-p)\underline{x}) - \overline{x} \\ \overline{m}_5 &= 0 \\ \overline{m}_6 &= \overline{x} - X \\ \overline{m}_7 &= m_{max} \end{aligned}$$

The value of the call options in period t and $t+1$ associated with these strategies is given in the following table.

	$\overline{C}_t$	$\overline{C}_{t+1}$	$\underline{C}_{t+1}$
$\overline{m}_1$	0	$(1-p)(\overline{x}-\underline{x})-m_{min}$	$-p(\overline{x}-\underline{x})-m_{min}$
$\overline{m}_2$	0	$\overline{x}-\underline{x}$	0
$\overline{m}_3$	δX	$2(1-p)(\overline{x}-\underline{x})$	0
$\overline{m}_4$	0	$2(1-p)(\overline{x}-\underline{x})+\delta X$	0
$\overline{m}_5$	$(1-p)(\overline{x}-\underline{x})+\delta X$	$(1-p)(\overline{x}-\underline{x})$	0
$\overline{m}_6$	$2(1-p)(\overline{x}-\underline{x})+\delta X$	0	0
$\overline{m}_7$	$(1-p)(\overline{x}-\underline{x})+\delta X+m_{max}$	0	0

The strategies $\overline{m}_3$ and $\overline{m}_5$, which are consistent with the analysts' expectations are both dominated strategies. Thus, given the analysts' beliefs $F_{t+1}=X=p\overline{x}+(1-p)\underline{x}$, the manager is always better off if she deviates from the strategy consistent with these beliefs. In particular, the manager's utility is maximal if she follow either strategy $\overline{m}_1=m_{min}$ or strategy $\overline{m}_7=m_{max}$ in dependance on the parameter of the utility function, i.e. δ and θ.

Consider next the case $x_t=\underline{x}$ where the manager aims to find some $\overline{m}\in[m_{min},m_{max}]$ that maximizes (B.49) given $F_{t+1}=X=p\overline{x}+(1-p)\underline{x}$. Then, the manager's utility would change when the manager switches between the following strategies:

$$
\begin{aligned}
\underline{m}_1 &= m_{min}\\
\underline{m}_2 &= \underline{x}-X\\
\underline{m}_3 &= 0\\
\underline{m}_4 &= \overline{x}-X\\
\underline{m}_5 &= X-\delta(p\overline{x}+(1-p)\underline{x})-\underline{x}\\
\underline{m}_6 &= p\overline{x}+(1-p)\underline{x}-\underline{x}\\
\underline{m}_7 &= m_{max}
\end{aligned}
$$

The value of the call options in period t and $t+1$ associated with these strategies is given in the following table.

	$\underline{C}_t$	$\overline{C}_{t+1}$	$\underline{C}_{t+1}$
$\underline{m}_1$	0	$(1-p)(\overline{x}-\underline{x})-m_{min}$	$-p(\overline{x}-\underline{x})-m_{min}$
$\underline{m}_2$	0	$\overline{x}-\underline{x}$	0
$\underline{m}_3$	0	$(1-p)(\overline{x}-\underline{x})$	0
$\underline{m}_4$	0	0	0
$\underline{m}_5$	0	0	0
$\underline{m}_6$	δX	0	0
$\underline{m}_7$	$-p(\overline{x}-\underline{x})+\delta X+m_{max}$	0	0

Thus, the strategies $\underline{m}_6$ and $\underline{m}_3$ consistent with the analysts' beliefs are both dominated strategies. Thus, given the analysts' beliefs $F_{t+1}=X=p\overline{x}+(1-p)\underline{x}$, the manager is always better if she deviate from the strategies consistent with these beliefs. In particular, the manager's utility is maximal if she follows either strategy $\overline{m}_1 = m_{min}$ or strategy $\overline{m}_7 = m_{max}$ in dependance on the parameter δ and θ.

If the manager chooses to play $\overline{m} = \underline{m} = m_{min}$ or $\overline{m} = \underline{m} = m_{max}$ the analysts would change their beliefs in equilibrium so that $F_{t+1} = p\overline{x} + (1-p)\underline{x} - m_{min}$ respectively $F_{t+1} = p\overline{x} + (1-p)\underline{x} - m_{max}$.

Consider first the case where $F_{t+1} = p\overline{x} + (1-p)\underline{x} - m_{min}$. This is an equilibrium strategy if the manager prefers to play $\overline{m} = \underline{m} = m_{min}$ to any other strategy. In order to derive conditions for which this is true we evaluate the value of the stock options in both periods associated with the different manipulation strategies available to the manager given that $F_{t+1} = p\overline{x} + (1-p)\underline{x} - m_{min}$. The strategies available to the manager are:

$$\begin{aligned}
\overline{m}_1 &= m_{min}\\
\overline{m}_2 &= \underline{x} - X\\
\overline{m}_3 &= 0\\
\overline{m}_4 &= \overline{x} - X\\
\overline{m}_5 &= m_{max}
\end{aligned}$$

respectively

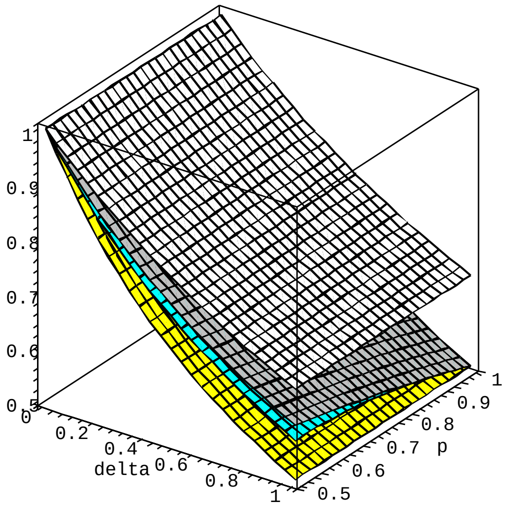
$$\begin{aligned}
\underline{m}_1 &= m_{min}\\
\underline{m}_2 &= \underline{x} - X\\
\underline{m}_3 &= 0\\
\underline{m}_4 &= \overline{x} - X\\
\underline{m}_5 &= m_{max}
\end{aligned}$$

The following table summarizes the value of the stock options in both periods associated with these strategies.

	$\overline{C}_t$	$\overline{C}_{t+1}$	$\underline{C}_{t+1}$
$\overline{m}_1$	$\overline{x} - X + m_{min} + \delta(X - m_{min})$	$(1-p)(\overline{x} - \underline{x}) - m_{min}$	$-p(\overline{x} - \underline{x}) - m_{min}$
$\overline{m}_2$	$(1-2p)(\overline{x} - \underline{x}) + \delta(X - m_{min})$	$\overline{x} - \underline{x}$	0
$\overline{m}_3$	$\overline{x} - X + \delta(X - m_{min})$	$(1-p)(\overline{x} - \underline{x})$	0
$\overline{m}_4$	$2(1-p)(\overline{x} - \underline{x}) + \delta(X - m_{min})$	0	0
$\overline{m}_5$	$\overline{x} - X + m_{max} + \delta(X - m_{min})$	0	0
$\underline{m}_1$	0	$(1-p)(\overline{x} - \underline{x}) - m_{min}$	$-p(\overline{x} - \underline{x}) - m_{min}$
$\underline{m}_2$	0	$\overline{x} - \underline{x}$	0
$\underline{m}_3$	$-p(\overline{x} - \underline{x}) + \delta(X - m_{min})$	$(1-p)(\overline{x} - \underline{x})$	0
$\underline{m}_4$	$(1-2p)(\overline{x} - \underline{x}) + \delta(X - m_{min})$	0	0
$\underline{m}_5$	$-p(\overline{x} - \underline{x}) + m_{max} + \delta(X - m_{min})$	0	0

where $X := p\overline{x} + (1-p)\underline{x}$. The next figure illustrates for which parameters θ, p, and δ the manager's payoff is maximal if she chooses the strategy $\overline{m}_1 = m_{min}$.

Figure B.6: Restrictions on θ satisfying the equilibrium conditions for the case $x_t = \overline{x}$ given that $F_{t+1} = p\overline{x} + (1-p)\underline{x} - m_{min}$



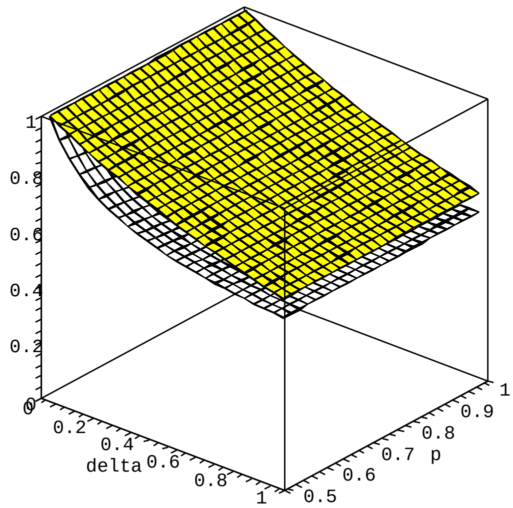
The manifolds determine the subsets of parameters for which certain payoffs are equal. The subset of parameters above the lowest manifold is such that $\overline{u}^M(\overline{m}_1) > \overline{u}^M(\overline{m}_2)$. The subset of parameters above the next two manifolds is such that $\overline{u}^M(\overline{m}_1) > \overline{u}^M(\overline{m}_3)$ and $\overline{u}^M(\overline{m}_1) > \overline{u}^M(\overline{m}_4)$. The subset of parameters above the manifolds on the top is such that $\overline{u}^M(\overline{m}_1) > \overline{u}^M(\overline{m}_5)$.

Thus, given that $F_{t+1} = p\overline{x} + (1-p)\underline{x} - m_{min}$ the manager chooses $\overline{m} = m_{min}$ if $\overline{u}^M(\overline{m}_1) > \overline{u}^M(\overline{m}_5)$, which is true for

$$\theta > \frac{2}{2+\delta} \tag{B.50}$$

If condition (B.50) holds, the manager would also choose $\underline{m}_1 = m_{min}$ since $\underline{u}^M(\underline{m}_1) > \underline{u}^M(\underline{m})$ for any $p \in [0,1]$ and $\delta \in [0,1]$. This is illustrated in the following figure.

Figure B.7: Restrictions on θ for which $\overline{u}^M(\overline{m}_1) > \overline{u}^M(\overline{m}_5)$ and $\underline{u}^M(\underline{m}_1) > \underline{u}^M(\overline{m}_5)$ given that $F_{t+1} = p\overline{x} + (1-p)\underline{x} - m_{min}$



The manifolds determine the subsets of parameters for which certain payoffs are equal. The subset of parameters above the lowest manifold is such that $\underline{u}^M(\overline{m}_1)$ is maximal. The subset of parameters above the manifolds on the top is such that $\overline{u}^M(\overline{m}_1)$ is maximal.

Consider now the case where $F_{t+1} = p\overline{x} + (1-p)\underline{x} - m_{max}$. The manager can choose between the same manipulation strategies as in the case where $F_{t+1} = p\overline{x} + (1-p)\underline{x} - m_{min}$. The value of her stock options changes as follows.

	$\overline{C}_t$	$\overline{C}_{t+1}$	$\underline{C}_{t+1}$
$\overline{m}_1$	0	$(1-p)(\overline{x}-\underline{x}) - m_{min}$	$-p(\overline{x}-\underline{x}) - m_{min}$
$\overline{m}_2$	0	$\overline{x}-\underline{x}$	0
$\overline{m}_3$	$-p(\overline{x}-\underline{x}) + \delta(X - m_{max})$	$(1-p)(\overline{x}-\underline{x})$	0
$\overline{m}_4$	$2(1-p)(\overline{x}-\underline{x}) + \delta(X - m_{max})$	0	0
$\overline{m}_5$	$(1-p)(\overline{x}-\underline{x}) + \delta(X - m_{max}) + m_{max}$	0	0
$\underline{m}_1$	0	$(1-p)(\overline{x}-\underline{x}) - m_{min}$	$-p(\overline{x}-\underline{x}) - m_{min}$
$\underline{m}_2$	0	$\overline{x}-\underline{x}$	0
$\underline{m}_3$	0	$(1-p)(\overline{x}-\underline{x})$	0
$\underline{m}_4$	0	0	0
$\underline{m}_5$	$-p(\overline{x}-\underline{x}) + m_{max} + \delta(X - m_{max})$	0	0

for $\delta < \frac{2(p-1)}{2p-3}$.

Thus, the manager chooses $\overline{m} = m_{max}$ but also $\underline{m} = m_{max}$ if $\underline{u}^M(\underline{m}_5) > \underline{u}^M(\underline{m}_1)$. This is true for

$$\theta < \frac{2(1-p) + \delta(2p-3)}{2(1-p) + \delta(2p-1)} \tag{B.51}$$

B.5 Proof of Theorem 5

If $v(.) \neq 0$ the manager's payoffs in both states are:

$$\begin{aligned} \overline{u}^M(.) &= (1-\theta)\max[\overline{x}+\overline{m}+\delta\overline{F}_{t+1}+v(\overline{x}+\overline{m}-F_t)-X,0] \\ & \quad \delta\theta p\max[\overline{x}-\overline{m}+v(\overline{x}-\overline{m}-\overline{F}_{t+1})-X,0] \\ & \quad +\delta\theta(1-p)\max[\underline{x}-\overline{m}+v(\underline{x}-\overline{m}-\overline{F}_{t+1})-X,0] \end{aligned} \tag{B.52}$$

and

$$\begin{aligned} \underline{u}^M(.) &= (1-\theta)\max[\underline{x}+\underline{m}+\delta\underline{F}_{t+1}+v(\underline{x}+\underline{m}-F_t)-X,0] \\ & \quad \delta\theta p\max[\overline{x}-\underline{m}+v(\overline{x}-\underline{m}-\underline{F}_{t+1})-X,0] \\ & \quad +\delta\theta(1-p)\max[\underline{x}-\underline{m}+v(\underline{x}-\underline{m}-\underline{F}_{t+1})-X,0] \end{aligned} \tag{B.53}$$

where the function $v(.)$ is defined as in (3.3) and $X := p\overline{x}+(1-p)\underline{x}$ as before.

Consider first the case where the manager aims to find some $\overline{m} \in [m_{min}, m_{max}]$ that maximizes (B.52) given $\overline{F}_{t+1}$. Suppose that in equilibrium $\overline{F}^*_{t+1} = X = p\overline{x}+(1-p)\underline{x}$. Then, the manager's marginal utility would change when the manager switches between the following strategies:

$$\begin{aligned} \overline{m}_1 &= m_{min} \\ \overline{m}_2 &= \underline{x}-X = -p(\overline{x}-\underline{x}) \\ \overline{m}_3 &= X-\overline{x} = -(1-p)(\overline{x}-\underline{x}) \\ \overline{m}_4 &= 0 \\ \overline{m}_5 &= \overline{x}-X = (1-p)(\overline{x}-\underline{x}) \\ \overline{m}_6 &= m_{max} \end{aligned} \tag{B.54}$$

The value of the stock options in both periods associated with these strategies are given in the following table.

	$\overline{C}_t$	$\overline{C}_{t+1}$	$\underline{C}_{t+1}$
$\overline{m}_1$	0	$2(1-p)(\overline{x}-\underline{x})-2m_{min}$	$-2p(\overline{x}-\underline{x})-2m_{min}$
$\overline{m}_2$	0	$\overline{x}-\underline{x}$	0
$\overline{m}_3$	$2(1-p)(\overline{x}-\underline{x})+\delta X$	$2(1-p)(\overline{x}-\underline{x})$	0
$\overline{m}_4$	δX	$3(1-p)(\overline{x}-\underline{x})+\overline{x}$	0
$\overline{m}_5$	$4(1-p)(\overline{x}-\underline{x})+\delta X$	0	0
$\overline{m}_6$	$2(1-p)(\overline{x}-\underline{x})+2m_{max}+\delta X$	0	0

Thus, given that $F_t = \overline{F}_{t+1} = X = p\overline{x}-+(1-p)\underline{x}$ for any $\theta \in [0,1]$ the strategies $\overline{m}_3$ and $\overline{m}_4$, which are consistent with the analysts' forecasts are dominated. Moreover, if the analysts forecasts are $F_t = \overline{F}_{t+1} = X = p\overline{x}+(1-p)\underline{x}$, the manager chooses either $\overline{m}_1 = m_{min}$ or $\overline{m}_6 = m_{max}$. Thus, in equilibrium the analysts would change their beliefs.

Suppose that the analysts best forecasts are $F_t = X + m_{min}$ and $\overline{F}_{t+1} = X - m_{min}$. Then, the manager can choose among the following manipulation strategies:

$$\begin{aligned}
\overline{m}_1 &= m_{min} \\
\overline{m}_2 &= \overline{x} - X + m_{min} = (1-p)(\overline{x} - \underline{x}) + m_{min} \\
\overline{m}_3 &= 0 \\
\overline{m}_4 &= m_{max}
\end{aligned} \tag{B.55}$$

The value of the stock options in both periods associated with these strategies is summarized in the following table.

	$\overline{C}_t$	$\overline{C}_{t+1}$	$\underline{C}_{t+1}$
$\overline{m}_1$	$2(1-p)(\overline{x}-\underline{x}) + \delta X + (1-\delta)m_{min}$	$2(1-p)(\overline{x}-\underline{x}) - m_{min}$	0
$\overline{m}_2$	$4(1-p)(\overline{x}-\underline{x}) + \delta X + (1-\delta)m_{min}$	$-m_{min}$	0
$\overline{m}_3$	$2(1-p)(\overline{x}-\underline{x}) + \delta X - (1+\delta)m_{min}$	0	0
$\overline{m}_4$	$2(1-p)(\overline{x}-\underline{x}) + \delta X - (3+\delta)m_{min}$	0	0

The strategies $\overline{m}_2$ and $\overline{m}_3$ are dominated by $\overline{m}_4$ for any $\theta \in [0,1]$. Thus, given $F_t = X + m_{min}$ and $\overline{F}_{t+1} = X - m_{min}$, the strategy $\overline{m}_1 = m_{min}$ is an equilibrium strategy if $\overline{u}^M(\overline{m}_1) \geq u^M(\overline{m}_4)$. This is true for

$$\theta \geq \frac{4}{4 + 3\delta p - 2\delta p^2} \tag{B.56}$$

If $x_t = \underline{x}$ the manager can choose among the following manipulation strategies:

$$\begin{aligned}
\underline{m}_1 &= m_{min} \\
\underline{m}_2 &= \underline{x} - X + m_{min} = (1-p)(\overline{x} - \underline{x}) + m_{min} \\
\underline{m}_3 &= X - \underline{x} + m_{min} = p(\overline{x} - \underline{x}) + m_{min} \\
\underline{m}_4 &= 0 \\
\underline{m}_5 &= m_{max}
\end{aligned} \tag{B.57}$$

The value of the stock options in both periods associated with these strategies is summarized in the following table.

	$\underline{C}_t$	$\overline{C}_{t+1}$	$\underline{C}_{t+1}$
$\underline{m}_1$	0	$2(1-p)(\overline{x}-\underline{x}) - m_{min}$	0
$\underline{m}_2$	0	$-m_{min}$	0
$\underline{m}_3$	$\delta X + (1-\delta)m_{min}$	0	0
$\underline{m}_4$	$\delta X - p(\overline{x}-\underline{x}) - (1+\delta)m_{min}$	0	0
$\underline{m}_5$	$\delta X - 2p(\overline{x}-\underline{x}) + (3+\delta)m_{max}$	0	0

for $\beta > \frac{2(1-p)}{2p-1}$.

The strategy $\underline{m}_1 = m_{min}$ would be an equilibrium strategy of the manager if $\underline{u}^M(\underline{m}_1)$ is the maximum utility the manager can achieve given the forecasts of the analysts. Since the strategies $\underline{m}_4$ and $\underline{m}_3$ are dominated by $\underline{m}_5$ and the strategy $\underline{m}_2$ is dominated by $\underline{m}_1$ the strategy $\underline{m}_1$ is the best if $\underline{u}^M(\underline{m}_1) > \underline{u}^M(\underline{m}_5)$ which is equivalent to $\theta > \frac{\underline{C}_t(\underline{m}_5)}{\delta p \overline{C}_{t+1}(\overline{m}_1) + \underline{C}_t(\underline{m}_5)}$. Recall that the condition (B.56) is equivalent to $\theta >$

$\frac{\overline{C}_t(\overline{m}_5)-\overline{C}_t(\overline{m}_1)}{\delta p\overline{C}_{t+1}(\overline{m}_1)+\overline{C}_t(\overline{m}_5)-\overline{C}_t(\overline{m}_1)}$. Thus, if (B.56) holds, the condition $\theta > \frac{\underline{C}_t(\underline{m}_5)}{\delta p\overline{C}_{t+1}(\overline{m}_1)+\underline{C}_t(\underline{m}_5)}$ would not be binding since $\underline{C}_t(\underline{m}_5) < \overline{C}_t(\overline{m}_5)$.

Suppose now that the analysts' best forecasts are $F = p\overline{x}+(1-p)\underline{x}+m_{max}$ and $F_{t+1} = p\overline{x}+(1-p)\underline{x}-m_{max}$. This is an equilibrium strategy, if the manager would play $\overline{m} = \underline{m} = m_{max}$. However, if investors are loss averse, i.e. $\beta > 1$, the manager would never play $\underline{m} = m_{max}$, since this is a dominated strategy. This is because $\underline{C}_t(\underline{m} = m_{max}) > 0$ only if $\beta < \frac{(1-\delta)(X-m_{max})-\underline{x}}{\underline{x}-X}$. This condition is greater than 1 only if $\delta < \frac{m_{max}-2(X-\underline{x}}{m_max-X}$, which is negative if we assume that $m_{max} = \overline{x}-\underline{x}$. Thus, if investors are loss averse, i.e. $\beta > 1$, the manager would never choose to play $\underline{m} = m_{max}$ in equilibrium given that the analysts expect them to do so. Thus, this strategy is not part of the Bayesian Nash equilibrium (in pure strategies).

B.6 Proof of Theorem 6

The optimal forecasts of the guided analysts given their payoff function (3.7) with $\overline{n} = \overline{m}$ and $\underline{n} = \underline{m}$ are:

$$F_t^* = p\overline{x}+(1-p)\underline{x}+p\overline{m}+(1-p)\underline{m} \tag{B.58}$$

and

$$F_{t+1}^* = p\overline{x}+(1-p)\underline{x}-\mu\overline{m}-(1-\mu)\underline{m} \tag{B.59}$$

Given the best response of the analysts to the manager providing guidance with respect to the earnings she are about to shift over time, the manager's payoff in both states is:

$$\begin{aligned}\overline{u}(.)^M &= (1-\theta)[\overline{x}+\overline{m}+\delta(p\overline{x}+(1-p)\underline{x}-\mu\overline{m}-(1-\mu)\underline{m})] \\ &\quad +\delta\theta p[\overline{x}-\overline{m}]+\delta\theta(1-p)[\underline{x}-\overline{m}]\end{aligned} \tag{B.60}$$

respectively

$$\begin{aligned}\underline{u}(.)^M &= (1-\theta)[\underline{x}+\underline{m}+\delta(p\overline{x}+(1-p)\underline{x}-\mu\overline{m}-(1-\mu)\underline{m})] \\ &\quad +\delta\theta p[\overline{x}-\underline{m}]+\delta\theta(1-p)[\underline{x}-\underline{m}]\end{aligned} \tag{B.61}$$

Since $v(.) = 0$ the manager's payoff depends linearly on $\overline{m}$ respectively $\underline{m}$ so that the manager would either choose to play m_{max} or m_{min}. If the manager choses the same action in both states, i.e. $\overline{m} = \underline{m} \in \{m_{min}, m_{max}\}$, the outsiders' beliefs μ do not matter and the manager's payoff is:

$$\begin{aligned}\overline{u}(.)^M &= (1-\theta)[\overline{x}+\overline{m}+\delta(p\overline{x}+(1-p)\underline{x}-\overline{m}] \\ &\quad +\delta\theta p[\overline{x}-\overline{m}]+\delta\theta(1-p)[\underline{x}-\overline{m}]\end{aligned} \tag{B.62}$$

respectively

$$\begin{aligned}\underline{u}(.)^M &= (1-\theta)[\underline{x}+\underline{m}+\delta(p\overline{x}+(1-p)\underline{x}-\underline{m})] \\ &\quad +\delta\theta p[\overline{x}-\underline{m}]+\delta\theta(1-p)[\underline{x}-\underline{m}]\end{aligned} \tag{B.63}$$

The manager would therefore prefer to manipulate the earnings rather than to report truthfully if either

$$\theta < 1-\delta \text{ and } \overline{m} = m_{max} > 0 \tag{B.64}$$

or

$$\theta > 1-\delta \text{ and } \overline{m} = m_{min} < 0 \tag{B.65}$$

If $\theta = 1-\delta$, the manager is indifferent between earnings manipulation and truthful reporting. However, if the manager says that she is not going to manipulate the earnings and the analysts expect them to do so, they have strong incentives to deviate from the announced strategy. Thus, truthful reporting is not an equilibrium strategy for the manager guiding the analysts. Hence, a manager with $\theta = 1-\delta$, would decide to manipulate earnings up, i.e. $\overline{m} = \underline{m} = m_{max}$, since $1-\delta < \frac{1}{1+\delta}$ for any $0 < \delta \leq 1$ and $\overline{m} = \underline{m} = m_{max}$ is the optimal strategy of the manager with $\theta < \frac{1}{1+\delta}$.

B.7 Proof of Theorem 7

The optimal forecasts of the analysts given their payoff function (3.7) with $\overline{n} = \overline{m}$ and $\underline{n} = \underline{m}$ are:

$$F_t^* = p\overline{x} + (1-p)\underline{x} + p\overline{m} + (1-p)\underline{m} \tag{B.66}$$

$$F_{t+1}^* = p\overline{x} + (1-p)\underline{x} - \mu\overline{m} - (1-\mu)\underline{m} \tag{B.67}$$

Given the best response of the analysts to the manager guidance, the manager's payoffs are:

$$\begin{aligned}\overline{u}^M(.) \;\; = \;\; & (1-\theta)\max[\overline{x}+\overline{m}+\delta(p\overline{x}+(1-p)\underline{x}-\mu\overline{m}-(1-\mu)\underline{m})-X;0] \\ & +\delta\theta p\max[\overline{x}-\overline{m}-X;0] \\ & +\delta\theta(1-p)\max[\underline{x}-\overline{m}-X;0]\end{aligned} \tag{B.68}$$

respectively

$$\begin{aligned}\underline{u}^M(.) \;\; = \;\; & (1-\theta)\max[\underline{x}+\underline{m}+\delta(p\overline{x}+(1-p)\underline{x}-\mu\overline{m}-(1-\mu)\underline{m})-X;0] \\ & +\delta\theta p\max[\overline{x}-\underline{m}-X;0] \\ & +\delta\theta(1-p)\max[\underline{x}-\underline{m}-X;0]\end{aligned} \tag{B.69}$$

To determine the manager's optimal manipulation strategy while considering its impact on the best response of the analysts we consider different strategies. Given the manager's payoffs there are three reasonable candidates in both states, i.e. $\overline{m}_1 = \underline{m}_1 = m_{min}$, $\overline{m}_2 = \underline{m}_2 = 0$, or $\overline{m}_3 = \underline{m}_3 = m_{max}$. If $x_t = \overline{x}$, the manager's call options have the following values:

	$\overline{C}_t$	$\overline{C}_{t+1}$	$\underline{C}_{t+1}$
$\overline{m}_1$	0	$(1-p)(\overline{x}-\underline{x})-m_{min}$	$-p(\overline{x}-\underline{x})-m_{min}$
$\overline{m}_2$	$(1-p)(\overline{x}-\underline{x})+\delta X$	$(1-p)(\overline{x}-\underline{x})$	0
$\overline{m}_3$	$(1-p)(\overline{x}-\underline{x})+(1-\delta)m_{max}+\delta X$	0	0

Thus, the strategy $\overline{m}_2 = 0$ is a dominated strategy for any $\theta \in [0,1]$. The manager chooses $\overline{m}_1 = m_{min}$ if $\overline{u}^M(\overline{m}_1) > \overline{u}^M(\overline{m}_3)$, which is true for

$$\theta > \frac{(2-p-\delta)(\overline{x}-\underline{x})+\delta X}{(2-p)(\overline{x}-\underline{x})+\delta X} \tag{B.70}$$

Thus, if $\theta \in [0, \frac{(2-p-\delta)(\overline{x}-\underline{x})+\delta X}{(2-p)(\overline{x}-\underline{x})+\delta X}]$ the manager chooses $\overline{m}_3 = m_{max}$. If $x_t = \underline{x}$ the manager's call options have the following values.

	$\underline{C}_t$	$\overline{C}_{t+1}$	$\underline{C}_{t+1}$
$\underline{m}_1$	0	$(1-p)(\overline{x}-\underline{x})-m_{min}$	$-p(\overline{x}-\underline{x})-m_{min}$
$\underline{m}_2$	0	$(1-p)(\overline{x}-\underline{x})$	0
$\underline{m}_3$	$-p(\overline{x}-\underline{x})+m_{max}(1-\delta)+\delta X$	0	0

for $\delta < \frac{2p-2}{2p-3}$

The manager chooses the strategy $\underline{m}_3 = m_{max}$ if $\theta < \frac{\underline{C}_t(\underline{m}_3)}{\underline{C}_t(\underline{m}_3)-\delta m_{min}}$, which is equivalent to the condition (B.51).

Appendix C

To calibrate the model, we first need to reformulate the unknown parameters summarized in the vector β and noise terms summarized in the vector e so that they have the properties of probabilities. In particular, we treat each of the unknowns as a random variable with a compact support and $2 \leq M \leq \infty$ respectively $2 \leq J \leq \infty$ possible outcomes. Let the vector $z = z_1, ..., z_M$ be a set of M points spanning the possible unknown value of the vector of parameters β and the vector $v = v_1, ..., v_J$ be a set of J points spanning the possible values of the vector of noise terms ε. Then, each of the k parameters can be written as

$$\beta^k = \sum_{m=1}^{M} p_m^k z_m^k \tag{C.1}$$

and each of the n noise terms can be written as

$$e^n = \sum_{j=1}^{J} w_j^n v_j^n \tag{C.2}$$

with $\sum_{m=1}^{M} p_k^m = 1$ and $\sum_{j=1}^{J} w_n^j = 1$. The estimation problem is to recover the probability distributions for the unknown parameters and error terms that reconcile the available prior information with the observed sample information.

Using the reparameterized unknowns and the steady–state conditions of the linear-quadratic control problem we propose a GME solution to the problem that selects the probabilities p^k with $k = a, b, c, g, h$ where h is a Lagrange multiplier and w^n with $n = \varepsilon_1, \varepsilon_2$ to maximize

$$H(p^k, w^n) = -\sum_k \sum_M p_m^k \ln(p_m^k) - \sum_n \sum_J w_j^n \ln(w_j^n) \tag{C.3}$$

subject to

$$y_t = \sum_{m=1}^{M} p_m^a z_m^a y_{t-1} + G_t + \sum_{j=1}^{J} w_j^{\varepsilon_1} v_j^{\varepsilon_1} \tag{C.4}$$

$$G_t = \sum_{m=1}^{M} p_m^g z_m^g y_{t-1} + \sum_{j=1}^{J} w_j^{\varepsilon_2} v_j^{\varepsilon_2} \tag{C.5}$$

where $y_t = p_t - p_{t-1}$,

$$\sum_{m=1}^{M} p_m^g z_m^g = -\sum_{m=1}^{M} p_m^a z_m^a / \sum_{m=1}^{M} p_m^c z_m^c \tag{C.6}$$

$$\sum_{m=1}^{M} p_m^b z_m^b = -\sum_{m=1}^{M} p_m^h z_m^h + \delta(\sum_{m=1}^{M} p_m^a z_m^a + \sum_{m=1}^{M} p_m^c z_m^c \sum_{m=1}^{M} p_m^g z_m^g)^2 \sum_{m=1}^{M} p_m^h z_m^h \tag{C.7}$$

$$\sum_{m=1}^{M} p_k^m = 1 \text{ where } k = a, b, c, g, h \tag{C.8}$$

$$\sum_{j=1}^{J} w_n^J = 1 \text{ where } n = \varepsilon_1, \varepsilon_2 \tag{C.9}$$

Here, the objective function is the Shannon entropy (1948) of the distribution of probabilities. Equations (C.4), (C.5) together with the reparameterized steady–state conditions of the control problem (C.6) and (C.7) represent consistency relations. Equations (C.8) and (C.9) are additivity or normalization constraints.

Bibliography

[1] Ali, A., A. Klein and J. Rosenfeld, 1992. Analysts' Use of Information About Permanent and Transitory Earnings Components in Forecasting Annual EPS. The Accounting Review 67 (1), 183–198.

[2] Abarbanell, J., 1991. Do Analysts' Earnings Forecasts Incorporate Information in Prior Stock Price Changes. Journal of Accounting and Economics 14 (2), 147–165.

[3] Abarbanell, J. and V. Bernhard, 1992. Test of Analysts Overreaction/Underreaction to Earnings Information as an Explanation for Anomalous Stock Price Behaviour. The Journal of Finance 47, 1181–1207.

[4] Baker, M., R.S. Ruback, J. Wurgler, 2004. Behavioral Corporate Finance: A Survey. NBER Working Paper 10863.

[5] Baginski, S. and J. Hassell, 1990. The market interpretation of management earnings forecasts as a predictor of subsequent analyst forecast revisions. The Accounting Review 65 (1), 175–190.

[6] Barry, C.B. and S.J. Brown, 1985. Differential information and security market equilibrium. Journal of Financial and Quantitative Analysis 20, 407–422.

[7] Barth, M.E., J.A. Elliot, and M.W. Finn, 1999. Market Reward Associated with Patterns of Increasing Earnings. Journal of Accounting Research 37 (Autumn), 387–413.

[8] Bartov, E, D. Givoly, C. Hayn, 2002. The Reward of Meeting or Beating Earnings Expectations. Journal of Accounting and Economics 33 (June), 173–204.

[9] Bosworth, D. and M. Rogers, 1998. Research and Development, Intangible Assets and the Performance of Large Australian Firms, Melbourne Institute Working Paper No. 2.

[10] Brock, W. and C. Hommes, 1998. Heterogeneous beliefs and routes to chaos in a simple asset pricing model. Jornal of Economic Dynamics and Control 22, 1235–1274.

[11] Bowen, M., A. Davis and D. Matsumoto, 2002. Do Conference Calls Affect Analysts' Forecasts? The Accounting Review 77 (2), 285–316.

[12] Burgstahler, D. and I. Dichev, 1997. Earnings Management to Avoid Earnings Decreases and Losses. Journal of Accounting and Economics 24 (December), 99–126.

[13] Chan, L.K.C., J. Lakonishok, and Th. Sougiannis, 2001. The Stock Market Valuation of Research and Development Expenditures, Journal of Finance 56, 2431-2456.

[14] Chaney, P.K. and C.M. Lewis, 1994. Earnings Management and Firm Valuation Under Asymmteric Information. Journal of Corporate Finance 1, 319–245.

[15] Chow, G., 1975. Analysis and Control of Dynamic Economic Systems (Wiley, New York).

[16] Cotter, J., I. Tuna and P. Wysocki, 2006. Expectations Management and Beatable Targets: How Do Analysts React to Explicit Earnings Guidance? Contemporary Accounting Research 23 (3), 593-624.

[17] Degeorge, F., J. Patel and R. Zeckhauser, 1999. Earnings Management to Exceed Thresholds. Journal of Business 72 (1), 1–33.

[18] DeLong, J., A. Shleifer, L. Summers and R. Waldmann, 1990. Noise Trader Risk in Financial Markets. Journal of Political Economy 98 (4), 703–738.

[19] Doukas, J., Ch. Kim and Ch. Pantzalis, 2002. A Test of the Errors-in-Expectations Explanation of the Value/Glamour Stock Returns Performance: Evidence from Analysts' Forecasts. Journal of Finance 57 (5), 2143–2165.

[20] Easterwood, J. and S. Nutt, 1999. Inefficiency in Analysts Earnings Forecasts: Systematic Misreaction or Systematic Optimism? Journal of Finance 54, 1777–1797.

[21] Elliott, J., D. Philbrick and C. Wiedman, 1995. Evidence from archival data on the relation between security analysts' forecast errors and prior forecast revisions. Contemporary Accounting Research 11, 919-938.

[22] Fischer, P.E. and R.E. Verrecchia, 2000. Reporting Bias. The accounting Review 75 (2), 229–245.

[23] Freeman, R. N. and S. Y. Tse, 1992. A Nonlinear Model of Security Price Responses to Unexpected Earnings. Journal of Accounting Research 20 (2), 185–209.

[24] Golan, A., G. Judge and D. Miller, 1996. Maximum Entropy Economics: Robust Estimation with Limited Data. John Wiley&Sons.

[25] Griliches, Z., 1981. Market Value, R and D, and patents. Economic Letters 7, 193-7.

[26] Grabowski, H.G. and J.M. Vernon, 1990. A New Look at the Returns and Risks to Pharmaceutical R&D. Management Science 36 (7), 804-821.

[27] Graham, J.R., Harvey, C.R., and S. Rajgopal, 2005. The Economic Implications of Corporate Financial Reporting. Journal of Accounting and Economics 10 (1-3), 3–73.

[28] Guttman, I., O. Kadan and E. Kandel, 2004. A Rational Expectations Theory of the Kink in Earnings Reports. Working Paper.

[29] Hall, B.H., 1993. The Stock Market's Valuation of R&D Investment During the 1980's. American Economic Review 84, 259-264.

[30] Hall, B.H., 1999. Innovation and Market Value, NBER Working Paper No. 6984, Cambridge, MA.

[31] Hall, B.H. and D. Kim, 1997. Valuing Intangible Assets: The Stock Market Value of R&D Revised. UC Berkeley, Nuffield College, Harvard University, and NBER.

[32] Hall, B.H. and F. Hayashi, 1989. Research and Developement as an Investment. NBER Working Paper No. 2973.

[33] Hassell, J., R. Jennings and D. Lasser, 1988. Management earnings forecasts: their usefulness as a source of firm-specific information to security analysts. The Journal of Financial Research 11, 303–319.

[34] Heflin, F., K. Subramanyam and Y. Zhang, 2003. Regulation FD and the Financial Information Environment: Early Evidence. The Accounting Review 78 (1), 1–37.

[35] Himmelberg, C.P. and B.C. Petersen, 1994. R&D and Internal Finance: A Panel Study of Small Firms in High-tech Industries. Review of Economics and Statistics 76, 38-51.

[36] Hirschey, M. and J.J. Weygandt, 1985. Amortization Policy for Advertising and Research and Development Expenditures. Journal of Economic Research 23 (1), 326-335.

[37] Hsieh, P., T. Koller and S. Rajan, 2006. The Misguided Practice of Earnings Guidance. The McKinsey Quarterly, March 2006.

[38] Hong, J. and J. Kubik, 2003. Analyzing the Analysts: Career Concerns and Biased Earnings Forecasts. Journal of Finance 58, 313–351.

[39] Jaffe, A., 1986. Technological Opportunity and Spilloversof R&D: Evidence from Firms' Patents, Profits, and Market Value. American Economic Review 76, 984-1001.

[40] Jensen, M.C., 1993. The Modern Industrial Revolution, Exit and the Failure of Internal Control Systems. Journal of Finance 48, 831-880.

[41] Johnson, L.D., and B. Pazderka, 1993. Firm value and investment in R and D. Managerial and Decision Economics 14, 15-24.

[42] Kahneman, D. and A. Tversky, 1979. Prospect theory: An analysis of decisions under risk. Econometrica 47, 313–327.

[43] Kasznik, R. and M.F. McNichols, 2002. Does Meeting Earnings Expectations Matter? Evidence From Analyst Forecast Revisions and Share Prices. Journal of Acconting Research 40 (3), 727–759.

[44] Kinney, W. D. Burgstahler, and R. Martin, 2001. The Materiality of Earnings Surprise. Working paper.

[45] Lev, B. and Th. Sougiannis, 1996. The capitalization, amortization, and value-relevance of R&D. Journal of Accounting and Economics 21, 107-138.

[46] Lev, B. and Th. Sougiannis, 1999. Penetrating the book-to-market balck box: the R&D effect. Journal of Business Finance & Accounting 26 (3), 419-49.

[47] Lys, T. and S. Sohn, 1990. The Association between Revisions of Financial Analysts Earnings Forecasts and Security-Price Changes. Journal of Accounting and Economics 13, 341–363.

[48] Merton, R.C., 1987. A simple model of capital market equilibrium with incomplete information. The Journal of Finance 42, 483–510.

[49] Maines, L. and J. Hand, 1996. Individuals Perceptions and Misperceptions of Time Series Properties of Quarterly Earnings. Accounting Review 71 (3), 317-336.

[50] Mairesse, J. and M. Sassenou, 1991. R&D and Productivity: A Survey of Econometric Studies at the Firm Level, NBER Working Paper No. 3666.

[51] Matsumoto, D.A., 2002. Management's Incentives to Avoid Negative Earnings Surprises. The Accounting Review 77 (3), July.

[52] Matsunaga, S.R. and C.W. Park, 2001. The Effect of Missing a Quarterly Earnings Benchmark on the CEO's annual bonus. The Accounting Review 76, 313–332.

[53] McConnell, J. and H. Servaes, 1995. Equity Ownership and the Two Faces of the Debt. Journal of Financial Economics 39 (1), 131-157.

[54] Megna, P. and M. Klock, 1993. The Impact of Intangible Capital on Tobin's q in the Semiconductor Industry. AER Papers and Proceedings 83 (2), 265-269.

[55] Mendenhall, R., 1991. Evidence on the Possible Underweighting of Earnings- Related Information. Journal of Accounting Research. Spring, 170–179.

[56] Myers, S. and N. Majluf, 1984. Corporate financing and investment decisions when firms have information that investors do not have. Journal of Financial Economics 13, 187–222.

[57] Myers, L. and D. Skinner, 2001. Earnings momentum and earnings management. Working paper, University of Michigan.

[58] National Investor Relation Institute (NIRI), 2006. Corporate Disclosure Practice Survey, March 2006.

[59] Pakes, A., 1985. On Patents, R&D, and the Stock Market Rate of Return. The Journal of Political Economy 93 (2), 390-409.

[60] Raedy, J., P. Shane and Y. Yang, 2006. Horizon-Dependent Underreaction in Financial Analysts' Earnings Forecasts. Contemporary Accounting Research 23 (1), 219–322.

[61] Ramnath, S., S. Rock and Ph. Shane, 2006. A Review of Research Related to Financial Analysts' Forecasts and Stock Recommendations. Available at SSRN: http://ssrn.com/abstract=848248.

[62] Shannon, C.E., 1948. A Mathematical Theory of Communication. Bell System Technical Journal 27, 379–423.

[63] Sentana, E. and S. Wadhwani, 1992. Feedback Traders and Stock Return Autocorrelations: Evidence from a Century of Daily Data. Economic Journal 102, 415–425.

[64] Shefrin, H.M., 2001. Behavioral Corporate Finance. Journal of Applied Corporate Finance 14 (3), 113–124.

[65] Skinner, D. and R. Sloan, 2002. Earnings Surprises, Growth Expectations, and Stock Returns or Dont Let an Earnings Torpedo Sink Your Portfolio. Review of Accounting Studies 7, 289–312.

[66] Stein, J., 1989. Efficient Capital Markets, Ineffcient Firms: A Model of Myopic Corporate Behavior. The Quarterly Journal of Economics 104 (4), 655–669.

[67] Sougiannis, Th., 1994. The Acconting Based Valuation of Corporate R&D. The Accounting Review 69 (1), 44-68.

[68] Trueman, B. and S. Titman, 1988. An Explamation of Accounting Income Smoothing. Journal of Accounting Research 26 (supplement 1988), 127–139.

[69] Tversky, A. and D. Kahneman, 1979. Prospect Theory: an Analysis of Decision Under Risk. Econometrica 47, 263–292.

[70] Williams, P., 1996. The relation between a prior earnings forecast by management and analyst response to a current management forecast. The Accounting Review 71 (1), 103–115.

Curriculum Vitae

Personal Data

Name	Kremena Bachmann
Date of Birth	June 16, 1976
Nationality	Bulgarian

Education

1990 - 1995	High School in Bulgaria
1995 - 2002	University of St. Gallen Diploma Thesis ”Transferring Behavioral Finance into Practice”
2002 - 2007	Doctoral Program in Finance at the University of Zurich
2003 - 2004	Study Center Gerzensee: Program for Beginning Doctoral Students, Studies and Certificates in Microeconomics and Macroeconomics

Professional Experience

2000 - 2001	Credit Suisse Asset Management, Zurich
2002	Bank Wegelin&Co. Privatbankiers, St. Gallen
2002 - 2006	Research Assistant, NCCR FINRISK and Swiss Banking Institute, Chair of Financial Economics, University of Zurich